PROCEEDINGS

OF THE

Iowa Academy of Science

FOR 1907

VOLUME XIV

EDITED BY THE SECRETARY

PUBLISHED BY THE STATE

DES MOINES:
EMORY H. ENGLISH, STATE PRINTER
1907

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LETTER OF TRANSMITTAL.

DES MOINES, IOWA, Sept. 6, 1907.

To His Excellency, Albert B. Cummins, Governor of Iowa:

In accordance with the provisions of title 2, chapter 5, section 136, code 1897, I have the honor to transmit herewith the proceedings of the twenty-first annual session of the Iowa Academy of Science and request that you order the same to be printed.

Respectfully submitted,

L. S. ROSS,

Secretary Iowa Academy of Science.

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NORTON, W. H....................1900
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TRELEASE, WILLIAM .... Missouri Botanical Gardens, St. Louis, Mo.
UDDEN, J. A. .... Rock Island, Ill.
WEEMS, J. B. .... Alleghany, West Va.
WINSLOW, ARTHUR .... Kansas City, Mo.
YOUTZ, L. A. .... New York City, N. Y.

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Twenty-first Annual Meeting.

The twenty-first annual meeting of the Iowa Academy of Science was held in the rooms of the Physics department at Drake university, Des Moines, April 26 and 27, 1907. In the business session the following matters of general interest were presented:

REPORT OF THE SECRETARY.

TO THE MEMBERS OF THE IOWA ACADEMY OF SCIENCE:

The twentieth annual meeting of the Iowa Academy of Science was held at Ames on April 20 and 21, 1906. At this meeting two names were transferred from the list of members to that of fellows, nine were elected fellows and eighteen members, making a total increase in numbers of eleven fellows and sixteen members. Since the time of the meeting ten names have been dropped from the list, some by request and others because of non-payment of dues. The membership at present consists of 77 fellows, 70 members, and 55 corresponding members, making a total of 202.

Volume XIII of the proceedings contains the largest amount of matter of any volume issued. Even though brevier type was used the limit of 300 pages was reached and one lengthy paper was omitted because of want of space. The extreme delay in publication was due largely to a strike which put the state printer far behind with his work, and partially to slowness after the work began. Some of the papers for publication were not received by the secretary from the authors until August. Such delay can hardly be excusable. Work was not begun by the state printer until the latter part of September. There was a little delay at the bindery in getting the cloth bound copies ready, occasioned by a wait for some stock used.

In accord with the instructions of the Academy a better grade of paper was used for the reprints than that used in the bound volumes.

All the plates for illustration were allowed by the executive council. For reasons of economy the council directed that the illustrations be grouped together in the volume instead of being arranged with their respective articles. This detracts somewhat from the book but causes a saving of some $80 or $90 to the state.

The recent legislature changed the law so that instead of two, only one copy of the proceedings shall be sent to libraries and to members of the legislature.

The secretary very earnestly suggests the advisability of presenting in type written form all manuscripts intended for publication. So far as I know

there is no printer so thoroughly conversant with all the sciences that he can always correctly interpret pen marks that presumably are intended to convey some thought or impart some fact in some one of the fields of science entered by the members of the Academy; and I know there is no member of the Academy sufficiently grounded in all the sciences to be able to do this.

The rule with reference to the submitting of a brief abstract with each title is disregarded to a very considerable degree. It is to me a question whether such a rule be advisable. But so long as the Academy has the rule it should be enforced. An item of but little importance is the name of the Academy; is it the Iowa Academy of Sciences or the Iowa Academy of Science? The minutes seem to show that when the name was changed from The Iowa Association for Scientific Research that the new name adopted was The Iowa Academy of Science; but the plural form of the word, sciences, is that most frequently used.

For the sake of uniformity, it seems advisable that the Academy should adopt some ruling with reference to the capitalization of scientific names derived from proper names. In editing Vol. XIII the secretary perhaps rather arbitrarily changed the capitalized specific names to make them begin with lower case letters, believing it better to have uniformity in the volume in this respect. Respectfully submitted,

L. S. ROSS, Secretary.

MINUTES OF THE TWENTY-FIRST ANNUAL MEETING OF THE IOWA ACADEMY OF SCIENCE.

The sessions of the Academy were held at Drake university, Des Moines, Iowa, in the Physics lecture room, April 26 and 27, 1907.

At 1:30 o'clock P. M., April 26th, the president of the Academy, Professor C. O. Bates of Coe college, called the meeting to order. During the two days' session the following program was presented:

PROGRAM.

President's address, The Influence of Science in Training Ideals....C. O. Bates

1. Exposures of Iowan and Kansan (?) Drift, East of the Usually Accepted Boundary Line of the Driftless Area..........Ellison Orr
2. (a) Volcanic Phenomena Around Citlaltepetl and Popocatepetl, Mexico.
   (b) Significance of the Mesa de Maya.
   (c) Tertiary Terranes of New Mexico................Charles R. Keyes
3. A Visit to the Panama Canal (Illustrated)..............Grant E. Finch
4. The Channel of the Mississippi Between Lansing and Dubuque (Illustrated)..S. Calvin
5. (a) Recent Alluvial Changes in Southwest Iowa.
   (b) Effect of Certain Characteristics of Formations Upon Rate of Their Erosion ....J. E. Todd
6. The Loess of the Missouri River (Illustrated)................B. Shimek

7. The Orbit of the Asteroid, 1906, W. E..................E. B. Stouffer
8. A Catalog of the Poisonous Plants of Iowa...................... ....L. H. Pammel and Estelle D. Fogel
9. A Study of the Variation in the Number of Ray Flowers in Certain Compositae...W. S. Dudgeon
(Presented by L. H. Pammel.)
10. Iowa Erysiphacea..J. P. Anderson
11. Notes on Iowa Algae.................................R. E. Buchanan
12. The Homologies of Tissues in Ferns......................H. S. Conard
13. Studies in Karyokinesis....................................J. E. Gow
14. The Estimation of Silica..............................Nicholas Knight
15. The Recent Investigation of Iowa Ground Waters....W. S. Hendrickson
16. Some Problems in Municipal Sanitation.................L. H. Pammel
17. The Physical Science Laboratory of the State Normal (Illustrated) ....A. C. Page
18. The Lateral Line System of Amphiuma..................H. W. Norris

In addition to the regular program an evening meeting was held in the university auditorium, to hear a lecture by Professor H. L. Russell of the University of Wisconsin, on "Recent Discoveries with Reference to Insect Borne Diseases," and one by Professor W. W. Campbell, Director of the Lick Observatory, on "The Solar Eclipse in Spain."

On Friday afternoon a brief business meeting was held for the appointing of committees. Committees appointed were as follows:

Auditing: Pammel, Ross, Finch.
Membership: Hendrixson, Summers, Begeman.
Nominations: Ross, Norris, Ricker.
Resolutions: Tilton, Arey, Almy.
Secretary's Report: Ricker, Almy, Norris.

At 8:30 A. M., Saturday, April 27th, the council was called to order by President Bates to receive reports of committees. The minutes of the Twentieth annual meeting were read and were referred to the committee on secretary's report. The committee on membership offered the following report:

Names proposed for fellows: H. J. Hoeve, Des Moines; B. E. Shepperd, Des Moines; Henry S. Conard, Grinnell.

Names for members: N. C. Monroe, Fred J. Lazell, E. K. Chapman, C. W. Ellyson, T. C. Stevens, Joseph A. Anderson, F. V. Hanson, J. W. Morrison, Mark F. Boyd, J. W. Edwards, Henry Ness, F. J. Smith, Robert W. Getchell, Keith J. Irwin.

Names transferred to corresponding membership: Bruce Fink, Oxford, Ohio; T. E. Savage, Urbana, Ill.

Report of committee on resolutions: Your committee on resolutions present the following:

Resolved—

First: That we express our appreciation of the kindly manner in which the members of the Academy of Science have been entertained by the faculty and friends of Drake university and of the ample facilities for our meeting which the university has placed at our service.

Second: That we express appreciation of the most excellent lectures delivered at our evening session, April 26, by Professor H. L. Russell on the subject, "Recent Discoveries on Insect Borne Diseases," and Professor W. W. Campbell on "The Solar Eclipse in Spain."

Third: That we recognize the courtesy of the Greater Des Moines committee in entertaining the officers of this Academy at its luncheon Friday, April 25th.

Signed by the committee: John L. Tilton, M. F. Arey, Frank F. Almy.

Report of committee on secretary's report:

The committee commend the secretary for his care in editing Vol. XIII. We approve uniformity of capitalization in scientific names. We believe the secretary should insist upon the observance of the rule requiring typewritten copies for publication and that abstracts should be furnished by members.

Signed by the committee: Maurice Ricker, Frank F. Almy, H. W. Norris.

Report of committee on nominations:

For President, John L. Tilton; First Vice-President, C. L. Von Ende; Second Vice-President, Nicholas Knight; Secretary, L. S. Ross; Treasurer, H. E. Sumers; Executive committee, elective, L. Begeman, J. Fred Clark, R. B. Wylie. Report was presented by Mr. Ricker.

Signed by the committee: L. S. Ross, H. W. Norris, Maurice Ricker.

Reports of committees were received and adopted by the Council. A motion was made and carried that L. Begeman be elected a member of the Council. The Treasurer's report was received and referred to the auditing committee. The Council adjourned and the Academy was called to order. At the conclusion of the program a final business session of the Academy was held. The action of the Council was presented and was ratified. A committee consisting of Messrs. Pammel, Arey, and Bates was appointed to investigate the establishment of life memberships and the giving of prizes for specially meritorious work by members of the Academy. Also a committee consisting of Messrs. Ross, Summers, and Hendrixson was appointed to serve as a membership committee for one year; and said committee was instructed to revise the list of Academy members.

The treasurer was authorized to pay Professor W. W. Campbell twenty-five dollars for his lecture before the Academy Friday evening, April 26th.

The following resolution was adopted:

Resolved, That hereafter a Committee on Membership be appointed by the incoming President at the meeting at which he is elected, which committee shall serve until their successors are appointed; that a by-law providing for this be incorporated by the secretary.

An invitation was extended by Professor Calvin to the Academy to hold the next meeting at the State university. The place of meeting was left for the executive committee to determine. The Academy adjourned.

TREASURER'S REPORT.

RECEIPTS.

Cash on hand April 20, 1906	$ 172.62	
Sale of Proceedings	2.70	
Dues and Initiation Fees	145.00	
Interest on Deposits	6.00	$ 326.32

EXPENDITURES.

Printing	$ 5.25	
Expenses of Lecture, 1906	32.00	
Secretary's Honorarium for 1906-07	25.00	
Cash on hand April 26, 1907	264.07	$ 326.32

Respectfully submitted,

H. E. SUMMERS, Treasurer.

INFLUENCE OF MODERN SCIENCE IN THE FORMATION OF IDEALS.

PRESIDENTIAL ADDRESS.

BY C. O. BATES.

Gentlemen of the Academy:

Allow me to congratulate you on the completion of another year's successful and profitable work. Self-imposed scientific effort brings its own reward to every earnest soul in search of truth. The acquisition of new knowledge is both fascinating and stimulating. In proportion as we get knowledge at first hand, just in that proportion is the fascination and the stimulation increased, and our acquirements become a part of our being.

In 1819 Orested discovered that a wire carrying a current of electricity caused a magnetic needle to be deflected. This little and apparently insignificant force is, by a device for multiplication, running our elevators, propelling our street cars, and driving our machinery. The same force by a device for division is sending wireless messages across the ocean. Over two centuries ago Leeuwenhoek discovered an apparently insignificant class of microscopic organisms which on account of their rodlike shapes were termed bacteria. Today from a study of these organisms and their products, pestilences have been banished, disease conquered, and the average length of life increased by more than ten years. The miracle of the loaves and fishes was not more wonderful in some respects than the accomplishments of electro-magnetism, or of antitoxines.

Knowledge revealed through nature in this age is "as the rain that cometh down and the snow from Heaven, and returneth not thither, but watereth the earth, and maketh it to bring forth and bud that it may give seed to the sower and bread to the eater."

The scientific world moves apace; evidences of unrelaxing energy are apparent on every hand. A great discovery today does not astonish the world as it did a few generations ago. The discovery of the principle of the Leyden Jar in 1745 made a more profound impression in Europe and America than a similar discovery would make today.

This occasion gives me opportunity, not only to call attention to the magnificent work that has been done by the members of this body in discovering, collecting, and publishing scientific knowledge, sufficient each year to make a valuable volume, but also to speak of some things that are greater: namely, the indirect effects of scientific work upon the moral fibre and character of a progressive and prosperous people.

The old-time humanities developed an aristocratic class with a refined and selfish culture, and at the same time developed an ignorant class of slaves. A spirit of caste was developed and society became stratified as the various geological formations in the earth's crusts. It is the function of both science and religion to break up and pulverize these lines of stratification. Modern science answers the question of the ancient humanities as to who my neighbor is, by relieving suffering, prolonging life, by controlling and banishing disease, by uplifting humanity into one common brotherhood. It is the mission of science to help fill the hearts and minds of all with lofty and noble and true ideals. Science deepens reverence, banishes superstition, and exalts the truth. Science gives new standards of evidence; gives larger conceptions of duty and obligation, and enables us to make progress from a general knowledge of disconnected events to a special knowledge of phenomena connected by an invisible yet omnipresent law.

But it is said that the study of science has caused the distinction between that which is sacred and that which is secular to disappear; that parents, magistrates, judges, and ministers of the Gospel are not respected and honored as they formerly were; that religious creeds are losing their distinguishing characteristics; that the distinction between the pure and applied science is passing away; that the humanities are beginning to assume the garb of the utilities. It may be true that a mere taste of such a knowledge, by tearing down preconceived ideas, causes a lawless state of mind, but a deeper insight into scientific truth gives more reverence for law and order. Whatever of evil there is on account of this condition is to be remedied by more science. "A little knowledge is a dangerous thing."

Not until several decades yet to come can the fruit of scientific work be properly judged, but it is not difficult at present to discern the tendency of the times, and to observe the shaping of the great ideals for the education of future generations.

The methods of science have pervaded every department of human thought and enterprise. The so-called humanities of today have taken the methods of experimentation, testing, investigating, etc., rather than depend entirely upon tradition, dogma, and authority. Sociology is a science as to its methods and principles. Research in history is as scientific in its methods and plans as research in chemistry. Scientific investigations have modified and enlarged our knowledge of sacred history. It is destined to bring about the idea that every bush is a burning bush and that all ground is holy ground. "The hour cometh when ye shall neither in this mountain nor yet in Jerusalem worship the Father." "In every place incense shall be offered unto my name, and a pure offering: for my name shall be great among the heathen, sayeth the Lord of Hosts."

No scientific theory provoked so much discussion or brought about such a sharp conflict with theology as the theory of evolution. The warfare, however, is over, and every one is an evolutionist in a sense, but there are as many kinds of evolutionists as there are minds to conceive the theory. And the great Truth that stands out prominent as the result is the principle of unity, and to this principle it may be added that dogmatic theology and dogmatic science are equally objectionable.

The search for truth for truth's sake is always commendable, and commands the respect and the approval of an earnest and thoughtful people. We know but little about the matter. The ancients knew much less than we. The line of progress seems to lie in a better understanding of matter and its properties. In proportion as we comprehend and gain mastery over matter and the latent and vital energies that are associated with it, just in that proportion are we able to bring blessings to humanity and to understand God's revelations through nature. "Each new discovery," says John Fiske, "but places man upon a higher pinnacle than ever and lights the future with the radiant color of hope."

As knowledge increases, the domain of the natural world becomes enlarged and more real, while the domain of the supernatural world vanishes, and disappears as a myth. Reasoning from effect to cause has explained many strange phenomena, and at the same time disturbed the settled belief of many minds. The

belief in the law of the conservation of matter and of the conservation of energy in the physical world leads us direct to the future world, and makes it both natural and easy to accept the belief in the immortality of the soul.

Many bright minds of scientific bent and aptitude have appeared in the centuries gone by, but it seems that they were born out of season. Six hundred years ago the world was not ready for the great mind of Roger Bacon, when he taught that "Without experiment nothing can be adequately known. An argument proves theoretically, but does not give the certitude necessary to remove all doubt, nor will the mind repose in clear view of truth, unless it find it by way of experiment." "The strongest arguments prove nothing," said he, "so long as the conclusions are not verified by experience. Experimental science is the queen of sciences, and the goal of all speculation."

Three hundred years ago Dr. Wm. Gilbert wrote the following: "To you alone true philosophers, ingenuous minds, who not only in books, but in things themselves look for knowledge, have I dedicated a new style philosophising. But if any of you see fit not to agree with the opinions expressed, let them note the great multitude of experiments and discoveries, for it is these that cause all philosophy to flourish. We have dug them up and demonstrated them with much pains and sleepless nights, and great money expense."

The world had not then emerged from the dark ages long enough to appreciate and use the work of Dr. Gilbert on magnetism and electricity. They had to lie unheeded nearly two hundred years when Faraday put them to practical use. Contrast this state of affairs with the glorious achievements of science during the nineteenth century.

It is this style of study that our education must assume if it is to progress. It is necessary to present high ideals to the youth of our land in order to insure progress into a higher and better state of civilization. Mere animal drudgery is being swept away by the scientific applications of the forces of nature, and more intellectual callings are taking their place. Many artisans are losing their occupations on account of such changes. The scale of human labor is being diminished at the lower end while additions are being made higher up.

A large per cent of the so-called laboring class now find employment in many lines that were wholly unknown a century ago—telegraphy, stenography, and a thousand forms of mechanical

manipulation. The tendency of the age from this point of view is upward, helpful, and hopeful; and the science of this age is seen to be humanizing and elevating in its effects.

Such progress is not without some unavoidable evil effects. We always travel to permanent good through transitory ills. We are at present, as we always are, in a transitory period, with a golden age back of us, and a golden age in front of us; but the golden age of the future is a very different one from the golden age of the past. Likewise the tendency toward the combination of the forces in society and social life produces similar evils. A small business is absorbed by a large business; the large business is absorbed by a larger business; and the larger business is absorbed by the largest—namely the government. Each change brings about a greater per cent of efficiency while a large number of people are thrown out of employment, and as a consequence we have troubles of a serious character. These, however, have been evanescent in the past. We have gone through many such crises and we have many yet to pass through. Our hope lies in the universal scientific education.

The history of achievements and advancements in science has been for the most part a history of the work of the leaders in their respective fields of work. They have by their indomitable zeal breathed the breath of life into the institutions where they have labored. Henry put life into the Smithsonian institution, Washington, D. C.; Agassiz did the same thing for the museum of Harvard. So does every teacher and worker in scientific investigations, however humble he may appear to be, impress the minds and hearts of those with whom he associates, and help to establish their ideals.

The tide of popular appreciation of scientific accomplishments was never so high as at the present time. This appreciation does not partake of the spectacular phase of science work as it formerly did, nor of the bread and butter phase of the subject, but it is a widespread and deep feeling that our present state of civilization is superior to that of the past, and that this superiority is largely due to our advancement in science. It is not so much Edison, the wizard, or Marconi, the magician, as it is the exhibition of organized and trained common sense of Tyndall, Huxley, Pasteur, and Koch, and others that guides and governs the great mass of our intelligent people.

The cultural value of science is different from that of the humanities if it may be said to have a direct cultural value at all.

Its mission is rather to prepare the way for a higher and better culture, to expose that which is artificial, and to emphasize that which is real. Science is the forerunner of the greater Christian life yet to come. It is "The voice of one crying in the wilderness. Prepare ye the way of the Lord, make his paths straight."

We cannot expect immediate results in the influence of science studies in the formation and development of our higher ideals because much of the subject-matter lies outside the range of our ordinary experience. Molecules, atoms, and electrons do not belong to the same order of magnitude in which we live. They are as far removed from us on the one side, as the stars in the Heavens on the other side.

There is perhaps no phase of educational work so effective in multiplying, extending, and enlarging our mental concepts, as the study of the relative orders of magnitudes, together with the range and scope of properties in each. It requires an extension and penetration of the imagination that cannot be surpassed. The largest body we know anything about is the galaxy of stars above us. An infinitely smaller body would be an ordinary object we deal with in mechanics—a body that is familiar to us in our every day experience. Take another step downward infinite in distance and we come to the microscopic world where every man working with his highly magnifying lenses is a Columbus discovering new worlds. Take a third step downward infinite in distance below microscopic organisms and we come to another class of bodies definite, distinct, and as real as any bodies that we know of. These bodies are called molecules and atoms. It requires a new and different language for each order of magnitude. It is necessary to make a great deal of correction for parallax in order to get a true conception of the various bodies in scientific work.

Such wealth and variety of knowledge, together with the increased power of accumulating more knowledge, all of which leads to one great First Cause, is good material for building a noble character which shall endure unto the end. A character that will take into consideration the whole man, physical, intellectual, and moral. Righteousness and conscience are facts to be dealt with just as much as wood and stone.

"The thermometer is not so sensitive to heat, the barometer to weight, the photographer's plate to light, as is the soul to the ten thousand influences of its fellow men."

"Great is man's skill in handling engines of force; marvelous, man's control of winds and rivers; wondrous, the mastery of en-

gines and ideas. But the man himself is greater than the tools he invents, and man stands forth clothed with power to control and influence his fellows, in that he can sweeten their bitterness, allay their conflicts, bear their burdens, surround them with the atmosphere of hope and sympathy. Just in proportion as men have capacity, talent, and genius, are they to be guardians, teachers, and nurses for men, bearing themselves tenderly and sympathetically toward ignorance, poverty and weakness."

"Each Christian youth is to be a man-maker and man-mender. He is to help and not hurt men. This is to walk in love. This is to overcome evil with good. This is to be not a printed but a living gospel. This is to be a master of the art of right living and a teacher of the science of character building."

IOWA ERYSIPHACEAE.

BY J. P. ANDERSON.

INTRODUCTION.

The Erysiphaceæ are popularly known as blights, white or powdery mildews. They are parasitic on quite a large variety of plants and during the summer are often quite conspicuous factors of the vegetation, covering the leaves or other parts with a white mycelium which sometimes gives the host an almost hoary appearance.

The plant body proper consists of numerous branching, septate, usually white, much interwoven threads called the mycelium. These threads are superficial and adhere to and derive nutriment from the host by means of haustoria which arise from the mycelial threads and penetrate the epidermis of the host. An exception to this is found in Phyllactinia in which special branches of the mycelium enter the stomata of the host and send haustoria into the surrounding cells.

During the summer and early fall the asexual reproductive bodies or conidia are formed. They are cylindrical, oval or barrel-haped, colorless cells filled with protoplasm. They are formed by constriction at the ends of short, erect, simple, club-shaped, septate, colorless branches of the mycelium known as fertile hyphæ or conidiophores. The conidia are often found in chains, several from the end of the same hypha having fallen away together. The conidia are produced in immense numbers throughout the growing season, are light and easily carried by the wind, and serve for the rapid increase and wide distribution of the parasite as they germinate quickly under favorable conditions. In germinating the conidium sends out a slender tube which upon the proper host and under the proper conditions, soon develops into a new mycelium.

Later in summer or in autumn the true reproductive bodies or perithecia are formed. These perithecia contain the ascopores or

resting spores whose function seems to be to carry the fungus over from year to year.

The development of the perithecium is as follows: At the point where two hyphæ cross, or at the place where two neighboring hyphæ touch each develops a small upright branch which is soon separated from the parent hypha by a partition. One of these branches swells into an oval shape and becomes the carpogonium. The other elongates and applies itself closely to the carpogonium, curving above so that its end lies on the apex of the carpogonium. The upper part is then cut off by a septum and forms the antheridium. At the time of fertilization the wall between the two organs dissolves and the nucleus of the antheridium passes over and unites with nucleus of the carpogonium. A new wall is afterwards formed between the two organs.

The development of the walls of the future perithecium begins when the two nuclei unite. From the stalk cell of the carpogonium a number of hyphal branches grow upward forming a single layer around the carpogonium. Later the stalk cell swells and a second series internal to the first grow up in a similar manner.

When the perithecia are about half grown certain cells of the outer wall begin to grow out into appendages. These cells are situated either apically, equatorially, or basally. These appendages vary in character and with the number of asci form the character on which the genera are based. They are probably concerned with the distribution of the perithecia.

The perithecia when mature vary from globose to cup-shaped or pezzoid. They are generally blobose-depressed. The perithecia contain one to many asci each ascus containing two to eight colorless spores.

With the formation of the perithecia the mycelium sometimes completely disappears. Frequently, however, it is persistent.

The asci are liberated by the irregular rupture of the wall of the perithecium. The ascospores seem incapable of germination before passing through a resting stage. In a damp atmosphere or water they send out germ tubes, which on the epidermis of a suitable host plant penetrate and form a haustorium from which center the ordinary vegetative mycelium is produced.

Economically the Erysiphaceæ are very important. They injure many species of cultivated and native plants. As examples we need only cite the mildews infecting the grape, gooseberry, rose, cherry, plum, apple, and various forest and ornamental trees. They work injury by impairing the function of the leaf and causing a

premature dropping. Frequently other soft parts are also attacked which renders the injury to the host much greater. The loss to farmers and horticulturists through this source is often much greater than is at first apparent. The weakening of the vitality of the plant brings a less abundant harvest.

The choice of hosts by the various species of Erysiphaceæ is varied. Some, e. g. *Uncinula geniculata* on *Morus rubra*, are confined to one host plant. Others, e. g. *Uncinula circinata* on species of *Acer*, are confined to a single genus. Still others, e. g. *Uncinula salicis* on Salicaceæ, are confined to one family. Lastly, some grow on a great variety of host plants, e. g. *Erysiphe polygoni.*

Sometimes perithecia, when crushed, instead of emitting the usual asci emit a stream of small oblong spores 6.5—10.5$\times$3.5—6 micra immersed in a colorless gelatinous substance. In such cases smaller bodies oval to pyriform in shape will also be found. These rupture irregularly and emit the same kind of spores. Often these bodies are found where no perithecia have formed. They belong to a plant parasitic on the mildew. By careful examination the delicate hyphae of the parasite may be seen within the hyphae of the mildew. If the mildew attacked is in the perithecial stage the perithecium is filled with its fruits. If the mildew is in the conidial stage the attack of the parasite seems to prevent the formation of perithecia but the fruits of the parasite are often found in abundance. This parasite is *Ampelomyces quisqualis* Caseti. (See plate I.) It undoubtedly serves to hold the mildew in check. It seems to attack all species of Erysiphaceae. During the past two years it has been abundant in Decatur County, infesting the mildews on the following hosts:

Aster cordifolius L.
Aster laevis L.
Aster multiflorus Ait.
Aster salicifolius Lam.
Adicea pumila (L) Raf.
Ambrosia trifida integrifolia (Muhl.) T. & G.
Carduus altissimus L.
Cucumis sativa L.
Hydrophyllum virginicum.
Lactuca canadensis L.
Lactuca floridana (L.) Gaertner.
Lactuca sagittifolis Ell.
Monarda fistulosa L.
Physalis heterophylla Nus.

Rosa sp.
Rudbeckia laciniata L.
Solidago canadensis L.
Verbena urticifolia L.

In some cases, e. g. on the species of *Lactuca,* every specimen collected and examined proved to be infested by the *Ampelomyces* while in other instances, e. g. *Verbena urticifolia* only an occasional specimen was found.

Often conidia bearing mycelium is found on a host and no perithecia are formed. In Decatur County I have found conidia on the following hosts not reported under any species in this work. In the absence of perithecia it is impossible to definitely determine the species to which they belong:

Asclepias tuberosa L.
Aster multiflorus Ait.
Brassica sp. (Turnip.)
Cucumis sativa L.
Diospyros virginianum L.
Geum virginicum L.
Lactuca canadensis L.
Lactuca floridana (L.) Gaertn.
Lactuca sagittifolia Ell.
Monarda fistulosa L.
Physalis heterophylla Nus.
Potentilla monspeliensis L.
Rudbeckia laciniata L.
Rudbeckia triloba L.
Solanum carolinese L.
Solidago ulmifolia.
Xanthium canadense Mill.

To these should be added the following reported by Prof. Fink at Fayette in 1893:

Chrysanthemum sp. (Curt.)
Grindelia squarrosa (Pursh) Dunal.
Mesadenia tuberosa (Nutt.) Britt.
Phlox sp.
Physostegia virginiana (L.) Benth.
Roupa sylvestris (L.) Bess.
Sisymbrium officinale Scop.

On the same host plant perithecia may be formed one season but not another. During 1904 I looked for perithecia on *Verbena hastata* and *V. urticifolia* but found none although nearly every plant of the hosts were more or less affected with the conidial

stage of *E. cichoracearum.* In 1905 I found perithecia in abundance on both hosts.

The data contained in this paper are mainly the result of two years' observation on the family in Decatur County, together with an examination of the collections at the Iowa State College at Ames and the State University at Iowa City. The herbarium of Prof. B. Fink of Grinnell was also examined and the writer made some collections in Fremont and Ringgold counties. Unfortunately, a large portion of the collections at the State University were unavailable at the time of the writer's visit in June, 1905.

Synonyms are given only so far as the Iowa literature consulted is concerned. Following the name of the host plant are given in their order the locality, time, and collector of specimens on that host. If any of these items are lacking its place is taken by an X. The name of the collector is in parenthesis. An asterisk (*) indicates the writer has not seen the specimen so indicated but it has been reported in the literature consulted. The measurements given in the descriptions are adopted from Salmon's monograph of the family.

ACKNOWLEDGMENTS.

The writer's thanks are due to Prof. B. Fink of Grinnell for the privilege of examining his private collection, mostly from the vicinity of Fayette; to Profs. Macbride and Shimek for courtesies extended when examining the collections at the State University; to Prof. Pammel and his assistants of the State College for the privilege of examining the collections at Ames and assistance rendered; to Miss King of the botanical department at Ames who executed most of the drawings; and to others who assisted in various ways. Dr. Macbride has given much valuable information in regard to *Phyllactinia corylea tomentosa.*

LIST OF IOWA WORKS CONSULTED.

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Hitchcock, A. S.—Partial list of Iowa Powdery Mildews. Bulletin. Iowa Agri. College, Nov., 1886.

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ERYSIPHACEAE, Lev.

Parasitic on living plants. For further description see introduction.

KEY TO GENERA OF ERYSIPHACEAE.

Ascus Solitary—

Appendages of perithecium basal, floccose, similar to the mycelium........ .... *Sphaerotheca*

Appendages of perithecium or some of them dichotomously branched at apex .... *Podosphaera*

Asci Several—

Appendages of perithecium floccose, similar to the mycelium and frequently interwoven with it.. *Erysiphe*

Appendages of perithecium uncinate or coiled at apex............. *Uncinula*

Appendages of perithecium dichtomously branched at apex...... *Microsphaera*

Appendages of perithecium rigid, acicular, with a bulbous base.... *Phyllactinia*

SPHAEROTHECA, Lev.

Perithecia subglobose, ascus solitary, usually containing eight spores. Appendages simple, threads resembling the mycelium and often interwoven with it, rarely obsolete.

Key to Iowa Species of Sphaerotheca.

Mycelium persistent, thick and dense, with the perithecia more or less immersed.

Mycelium white, becoming gray or pale brown................. 3. *S. pannosa*

Mycelium becoming dark brown............................ 4. *S. mors-uvae*

Mycelium evanescent, subpersistent, or persistent, not thick and dense.

Inner wall of perithecium separating from outer.......... 5. *S. phytoptophila*

Inner wall of perithecium scarcely separating.

Cells of outer wall 10-20 micra wide..................... 1. *S. humuli*

Cells of outer wall 20-30 micra wide............. 2. *S. humuli fulginea*

1. *Sphaerotheca humuli,* (DC.) Burrill.

Sphaerotheca castagnei Lev. in part. Bessey, The Erysiphei and Prel. List Ames Flora. Hitchcock, Partial List Iowa Powdery Mildews. Fink, Blights, etc., of Fayette.

Sphaerotheca pruinosa C. & P. Bessey, The Erysiphei.

Sphaerotheca humuli (DC.) Burr. Fink, Blights, etc., of Fayette.

Sphaerotheca epilobi (Lk.) Sacc. Fink, in E. & E. N. A. Fungi.

Amphigenous; mycelium usually evanescent, sometimes persistent, forming white spots or patches on the upper surface of the leaf. Perithecia usually gregarious, sometimes scattered, 58-120 micra in diameter, cells small, 10-20 micra wide; appendages very variable as to length and color, sometimes even obsolete; ascus broadly elliptical to subglobose, 45-90x50-72 micra, spores 8, 20-25-12-18 micra.

On *Agrimonia hirsuta* (Muhl.) Bicknell, Ames, Oct. 15, 1878 (Bessey); Fayette (Fink).

On *Epilobium coloratum* (Muhl.), Ames, Aug. 25, 1894 (Combs); Fayette, Aug. 29, 1894 (Fink).

On *Rhus glabra* L. Iowa City, X (X).

On *Rosa arkansana* Porter, Ames, 1892 (Carver); Decatur Co., Oct., 1905 (Anderson).

This species is the destructive hop mildew. In Europe at times great losses are sustained by the hop grower through its ravages. It is found on the hop in some parts of America but has never been reported on that host in Iowa.

2. *Sphaerotheca humuli fulginea* (Schlecht), Salmon.

Sphaerotheca castaguei Lev. in part. Bessey, The Erysiphei, and Prel. List Ames Flora. Fink, Blights, etc., of Fayette. Hitchcock. Partial list Iowa Powdery Mildews.

As in *S. humuli* but the perithecia usually smaller, wall generally harder and more brittle; cells larger 20-30 micra or more wide; appendages pale to dark brown, usually short.

On *Bidens laevis* (L.), B. S. P. Ames, Aug. 25, 1894 (Combs).

On *Bidens frondosa* L., Ames, Aug. 22, 1877 (Bessey); Aug. 30, 1890 (Brown); Aug. 25, 1894 (Combs); *Aug., 1886 (Hitchcock); Decatur Co., 1904 and 1905 (Anderson); Fayette, Sept., 1893 (Fink).

On *Bidens involucrata* (Nutt), Britton, Decatur Co., Oct., 1905 (Anderson).

On *Bidens sp.*, Ames, Oct. 1, 1892 (X).

On *Erechitites hieracifolia* (L.), Raf., Ames, Oct. 12, 1878 (Bessey); Decatur Co., Oct. 10, 1904 (Anderson); Johnson Co., Sept. 16, 1899 (Shimek).

On *Leptandra virginica* (L.) Nutt, Ames, Sept. 21, 1878 (Bessey); Aug. 27, 1892 (Carver); Decatur Co., 1904 and 1905 (Anderson); Iowa City, Aug., 1888 (Macbride).

On *Leptilon canadense* (L.) Britt. *Fayette (X), (Fink).

On *Prunella vulgaris* L. Ames, Oct. 17, 1882 (Bessey).

On *Sonchus oleraceus*, L. *Fayette (Fink).

On *Taraxacum taraxacum* (L.), Karst. Ames, Sept. 4, 1894 (Combs); Decatur Co., Oct., 1904 (Anderson); Iowa City, Oct. 18, 1886 (Macbride); Oct. 3 (Bloom).

The variety is much more common in Iowa than the type. The type of the species is seldom collected while the variety is very common. Being confined to weeds it works no injury to man in Iowa.

3. *Sphaerotheca pannosa* (Wallr.), Lev.

Mycelium abundant on the stem leaves, petiole, calyx, etc., but the perithecia nearly always occurring on the stem, calyx or petiole, white, becoming gray to pale brown. Perithecia more or less immersed in the dense persistent mycelium, *globose to pyriform*, 85-120 micra in diameter, cells about 10 micra

wide, appendages few, sometimes obsolete, very short, tortuous, pale brown, septate. Ascus 88-115x0-75 micra. Spores 8, 20-27x12-15 micra.

On *Rosa blanda* Ait. Fayette, Aug., 1894 (Fink).

On *Rosa sp.*, Decatur Co., Nov. 18, 1905 (Anderson).

This species has been much confused with *S. humuli* and *S. mors-uvae.* Bessey and Hitchcock report it on species of *Ribes* but *S. mors-uvae* was undoubtedly the species intended. *S. humuli* occurs on the leaves of roses. *S. pannosa* in its conidial stage often attacks the entire end of the growing shoot of Crimson Rambler roses and thus does much damage to this variety as it is very common here in Decatur County. I have not observed it as destructive to other varieties. I have found the colored mycelium and perithecia only on the stems.

4. *Sphaerotheca mors-uvae* (Schwein), Berk and Curt.

See Plate II.

Sphaerotheca pannosa Lev. Bessey, Prel. List, Ames Flora; Hitchcock, Partial List Iowa Powdery Mildews.

Sphaerotheca mors-uvae (Schwein), Berk and Curt. Bessey, The Erysiphei, Fink, Blight, etc., of Fayette.

Mycelium abundant, at first white, becoming dark brown; forming dense patches on the fruit, stem and leaves. Perithecia mostly on the stem and fruit, gregarious, immersed in the persistent mycelium, 76-100 micra in diameter, cells 10-25 micra wide. Appendages few, pale brown, short and tortuous, rarely more numerous and longer. Ascus, 70-92x50-62 micra, rarely longer. Spores 20-25x12-15 micra.

On *Ribes cynosbati* L. Ames, July 3, 1876 (Bessey); Fayette, June 23 and 29, 1894 (Fink).

On *Ribes gracile* Michx. Ames, July 2, 1896 (Carver).

On *Ribes rotundifolium* Michx. *Ames, July, 1886 (Hitchcock); *Fayette (Fink).

On *Ribes sp.* Ames *(Bessey), 1894 (Carver); Decatur Co., June, 1904 and 1905 (Anderson).

This species is easily distinguished from all others by the dense, dark brown, felted mycelium. It attacks both wild and cultivated species of Ribes and is frequently quite injurious, especially to some cultivated varieties.

5. *Sphaerotheca phytoptophila,* Kellerm & Swingle.

Mycelium evanescent or subpersistent, perithecia gregarious, 60-78 micra in diameter, cells small, about 10 micra wide, often indistinguishable; appendages short, more or less tortuous; pale to dark brown, sometimes obsolete or long, *rarely branched;* ascus 60-75x42-50 micra; spores 8, 20-25x12-15 micra.

On *Celtis accidentalis* L., on the distortions caused by the Phytoptus. Ames, Jan., 1889 (Halsted).

This was distributed as No. 2336 of Ellis & Everhart's North American Fungi.

PODOSPHAERA, Kunze.

Perithecia globose or globose depressed; ascus solitary; spores 8. Appendages or some of them dichotomously branched at the apex. In *P. leucotricha* the appendages are of two kinds.

Key to Iowa Species of Podosphaera.

Appendages of one kind..1. *P. oxycanthae*
Appendages of two kinds...2. *P. leucotricha*

1. *Podosphaera oxycanthae* (DC.), DeBary.

Podosphaera kunzei Lev. Bessey, The Erysiphei.

Podosphaera minor Howe, Bessey, The Erysiphei.

Podosphaera tridactyla DBy. Bessey, Prel. List, Ames Flora. Hitchcock, Partial List Iowa Powdery Mildews.

Podosphaera oxycanthae (DC.), DBy. Fink, Blights, etc., of Fayette.

Amphigenous, mycelium variable, persistent or evanescent; perithecia scattered or gregarious in clinging masses, 64-90 micra in diameter, cells 10-18 micra wide; appendages 4-30 in number, ½-6 times the diameter of the perithecium, septate, dark brown for more than one-half their length, apex 2-4 times dichotomously branched, branches usually short, often swollen, tips recurved; ascus 58-99x45-75 micra; spores 18-30x10-17 micra.

On *Crataegus coccinea* L. Ames, X (X), Iowa City, July 9, 1894 (Shimek).

On *Crataegus punctata* Jacq. *Ames, July, 1886 (Hitchcock); Iowa City, Aug., 1886 (Hitchcock).

On *Crategus tomentosa* L. *Ames, July, 1886 (Hitchcock); Iowa City, Oct. 23, 1886 (Macbride).

On *Prunus americana* Marsh. Ames, 1891 (Raymond); Sept., 1890 (X); Decatur Co., Oct., 1904 (Anderson).

On *Prunus avium* L. Decatur Co., Aug. 31, 1905 (Anderson).

On *Prunus besseyi* Bailey. Decatur Co., Oct., 1904 (Anderson).

On *Prunus cerasus* L. Ames, Sept. 1, 1877 (Bessey), 1891 (Raymond), Sept., 1892 (Carver), Aug. 20, 1894 (Sexton), Sept. 13, 1894 (Stewart & Stewart), July 22, 1896 (Carver); Decatur Co., Aug., 1904 and 1905 (Anderson); Greenfield, Sept. 13, 1893 (Stewart); Iowa City, Oct. 1, 1886 (Macbride), 1895 (Shimek).

On *Prunus pumila* L. Ames, July 20, 1894 (Sexton), Aug. 31, 1894 (Stewart & Stewart), Oct. 19, 1892 (Carver).

On *Prunus sp.*, Ames, Sept. 9, 1892 (Pammel); Fayette, Sept., 1893 (Fink); *Ames, July, 1886 (Hitchcock).

On *Sanguisorba canandensis* L. Forest City, July 17, 1896 (Shimek).

This is a very common species, especially on the cultivated cherry *(Prunus cerasus)*. It distorts the leaf and causes premature drop-

ping thereby greatly weakening the vitality of the tree. On *Prunus cerasus* the perithecia usually occur on the under side of the leaf, while on the other hosts they are often found on the upper surface.

2. *Podosphaera leucotricha* (Ell. & Ever.), Salmon.

Sphaerotheca mali Burr. Fink, Blights, etc., of Fayette. Pammel, Powdery Mildew of the Apple, Cont. Bot. Dept. I. S. C., Iowa Acad. Sci., VII, 1899.

Mycelium, on the young stem petiole, and leaves, persistent, thin, effused; perithecia densely gregarious, rarely scattered, 75-90 micra in diameter, cells 10-16 micra wide; appendages of two kinds; apical appendages 3-11, 4-7 times the diameter of the perithecium, becoming thick walled, dark brown in the lower half, paler toward the tip, apex undivided or blunt, rarely once or twice dichotomously forked; basal appendages short, tortuous, pale brown; simple or irregularly branched; ascus 55-70x44-50 micra; spores 22-26x12-14 micra.

On *Malus malus* (L.) Britt. Ames, *July, 1894 (Pammel); Sept. 4, 1894 (Combs); Oct., 1894 (Carver); Fayette, Oct., 1893 (Fink).

This species often attacks young seedlings in the nursery and at times does considerable damage. It is generally classed as a *Sphaerotheca* but we feel inclined to agree with Mr. Salmon in placing it here. The appendages certainly show characteristics of both genera but the rigid apical appendages are certainly very unlike the appendages in *Sphaerotheca*. The occasional forking of the tips of the appendages certainly indicate that it is a *Podosphaera*.

ERYSIPHE, Hedw. f.

Perithecium containing several asci, each ascus 2-8 spored; appendages, threads similar to the mycelium and often interwoven with it. The appendages are rarely bosolete, or in the European *E. tortilis*, brown, assurgent and fasciculate.

Key to Iowa Species of Erysiphe.

Asci, 2-spored.

Perithecia, large, 135-240 micra in diameter, becoming pizzoid...5. *E. taurica*

Perithecia, 80-140 micra in diameter.

Haustoria lobed..3. *E. galeopsidis*

Haustoria, not lobed..................................2. *E. cichoracearum*

Asci, 3-8 spored.

Perithecia, 5-180 micra in diameter, usually about 90 micra.....1. *E. polygoni*

Perithecia, 130-280 micra in diameter, usually 180-200 micra....4. *E. graminis*

Erysiphe polygoni, DC.

See Plate III.

Erysiphe communis (Wallr.), Fr. Bessey, The Erysiphei, and Prel. List Ames Flora. Fink, Blight, etc., of Fayette.

Erysiphe martii Lev. Bessey, the Erysiphei, and Prel. List Ames Flora. Hitchcock, Partial List Iowa Powdery Mildews.

Erysiphe tortilis (Wallr.), Fr. Bessey, Prel. List Ames Flora. Hitchcock, Partial List Iowa Powdery Mildews.

Amphigenous; mycelium variable, thin, effused or abundant, persistent or evanescent; perithecia gregarious or scattered, 5-180 micra, usually about 90 micra in diameter, cells 10-15 micra wide; appendages very variable in number and length, ½-20 times the diameter of the perithecium, usually interwoven with the mycelium, colored at the base or throughout or rarely hyaline or white; asci 2-8, rarely mayn. 46-72x30-45 micra; spores 3-8, 19-25x9-14 micra.

On *Anemone canadensis* L. Iowa City, X (X).

On *Anemone sp.* Ames, 1894 (Carver).

On *Anemone virginiana* L. Ames, July 12, 1876 (Bessey).

On *Astragalus carolinianus* L. Ames, Sept. 9, 1894 (Combs); *Belle Plaine, Sept., 1886 (Hitchcock); Decatur Co., Sept., 1904, and Aug. and Sept., 1905 (Anderson); Decorah, Aug. 2, 1886 (Holway); Fayette, Sept., 1893 (Fink).

On *Brassica nigra* (L.) Koch. Fremont Co., Aug. 8, 1905 (Anderson).

On *Clematis virginiana* L. Ames, Oct., 1882 (Bessey), *Aug., 1886 (Hitchcock); Decatur Co., Sept., 1904 (Anderson); Iowa City, Oct. 10, 1886 (Macbride), Oct. 7, 1900 (Bloom). Oct., 1900 (Stromsten).

On *Falcata pitcheri* (T. & G.), Kunze, Decatur Co., Oct., 1905 (Anderson).

On *Geranium maculatum* L. Iowa City, Oct. 2 (Bloom).

On *Onagra biennis* (L.) Scop. Fayette, 1893 (Fink); Decorah, Sept. 17, 1879 (Holway).

On *Pisum sativum* L. Ames X (X); Decatur Co., June, 1905 (Anderson); Iowa City, May, 1886 (Macbride).

On *Polygonum aviculare* L, Ames, June 29, 1905 (Anderson); Decatur Co., July, 1904 and 1905 (Anderson).

On *Polygonum erectum* L. Decatur Co., July 12, 1905 (Anderson); Ringgold Co., Oct. 7, 1905 (Anderson).

On *Polygonum ramosissimum,* Michx. Fremont Co., Aug. 8, 1905 (Anderson).

On *Ranunculus abortivus* L. Ames, X (Rolfs); Decatur Co., July, 1904 and 1905 (Anderson); Iowa City, July, 1886 (Macbride).

On *Syndesman thalictroides* (L.), Hoffman, Iowa City, May, 1889 (Linder).

On *Thalictrum purpurascens* L. Decatur Co., July 12, 1905 (Anderson).

This is the most variable of our species of Erysiphaceae. Were it not that the character of the various extreme types intergrade into each other we would be inclined to consider various types as specifically distinct. Our specimens on *Polygonum* have appendages only ½-1½ times the diameter of the perithecium while on *Clematis* they sometimes reach a length of 15-20 times the diameter of the perithecium. Other Ranunculaceae show forms with appendages of intermediate length. Other characters also vary widely. In Decatur County *Onagra biennis* and *Syndesmon thalictroides* are

affected with the conidial stage but I have been unable to find perithecia.

The cultivated pea *(Pisum sativum)* is often seriously injured by this species. The other Iowa hosts are of but little importance economically with the exception of *Clematis* which is sometimes cultivated for ornament. During the seasons of 1904 and 1905 one could scarcely find a plant of *Polygonum erectum* but what was more or less affected and thus this weed was largely kept in check by the mildew.

Erysiphe cichoracearum, DC.

See Plate I.

Erysiphe cichoracearum, DC. Fink, Blights, etc., of Fayette.
Erysiphe horridula, Lev. Bessey, The Erysiphei.
Erysiphe lamprocarpa, Lev. Bessey, The Erysiphei and Prel. List Ames Flora; Hitchcock, Partial List Iowa Powdery Mildews; Halsted, in E. & E., N. A. Fungi (424).
Erysiphe linkii Lev. Halsted, in E. & E., N. A. Fungi (1904).
Erysiphe montagnei Lev. Bessey, The Erysiphei.
Erysiphe spadacea, Berk & Curt. Bessey, The Erysiphei.

Amphigenous; mycelium persistent or evanescent, haustoria not lobed; perithecia gregarious or scattered, 80-140 micra in diameter, very rarely larger, cells variable, 10-20 micra wide; appendages variable, generally colored and densely interwoven with the mycelium; asci 4-25 or more, more or less stalked, 58-90x30-50 micra; spores quite uniformly 2, rarely more, 20x28x12-20 micra.

On *Ambrosia artemisiaefolia*, L. Ames, Sept. 1, 1894 (Combs); Decatur Co., Aug. 13, 1905 (Anderson); *Fayette, 1894 (Fink); Iowa City, Sept. 30, 1886 (Macbride); Oct. 6, 1893 (Bloom).

On *Ambrosia trifida*, L. Ames, Aug. 25, 1894 (Combs); Sept. 5, 1873 (Bessey); *Aug., 1886 (Hitchcock); Decatur Co., Aug., 1904 and 1905 (Anderson); Fremont Co., Aug. 8, 1905 (Anderson); *Fayette, 1894 (Fink); Iowa City, Sept. 9, 1885 (Macbride); Oct. 7, 1893 (Bloom); Ringgold Co., Oct. 7, 1905 (Anderson).

On *Ambrosia trifida integrifolia* (Muhl.), T. & G. Ames, Sept. 22, 1894 (Combs); Decatur Co., Sept., 1905 (Anderson); Ringgold Co., Oct. 7, 1905 (Anderson).

On *Ambrosia psilostachya*, DC. *Fayette, 1893 (Fink).

On *Artemisia biennis*, Willd. Ames, Sept. 22, 1894 (Combs).

On *Artemisia gnaphaloides*, Nutt. Decorah, Sept., 1879 (Holway).

On *Artemisia serrata*, Nutt. Ames, Sept., 1887 (Halsted).

On *Aster cordifolius*, L., Iowa City, Oct. 11, 1893 (Bloom).

On *Aster laevis* L. Armstrong, Sept., 1895 (Shimek); Decatur Co., Sept., 1904 and 1905 (Anderson); Fremont Co., Aug. 7, 1905 (Anderson); Fayette, 1893 (Fink).

On *Aster sagittifolius*, Willd. Ames, Fall 1889 (X); Fayette, 1893 (Fink); Muscatine, Oct. 21, 1893 (Bloom).

On *Aster salicifolius* Lam. Ames, Oct. 15, 1877 (Bessey).
On *Aster sp.* Ames, Aug. 25, 1894, and Sept. 17, 1894 (Combs), *Fayette, 1893 (Fink).
On *Carduus altissimus*, L. Ames, Oct. 9, 1894 (Combs); Fayette, Sept., 1893 (Fink); Johnson Co., Sept. 28, 1886 (Macbride).
On *Carduus discolor* (Muhl.), Nutt. Ames, Sept. 12, 1894 (Combs), Oct. 19, 1892 (Carver); Sept. 9, X (Rolfs); Decatur Co., Oct., 1905 (Anderson); Ringgold Co., Oct. 7, 1905 (Anderson).
On *Cosmos bipinnatus*. Ames, Nov., 1893 (Carver), in greenhouse.
On *Eupnatorium perfoliatum*, L. Ames, Sept. 19, 1892 (Carver).
On *Eupatorium purpureum* L. Ames, Sept. 17, 1892 (Carver).
On *Galium circaezans* Michx. Decatur Co., Sept., 1904 and 1905 (Anderson).
On *Helenium autumnale*, L. Ames, Aug. 25, 1894 (Combs); Decatur Co., Oct., 1904 (Anderson); Johnson Co., Oct. 7, 1893 (Linder).
On *Helianthus annuus*, L. Ames, Sept. 8, 1892 (Carver); *Fayette, 1893 (Fink).
On *Helianthus doronicoides* Lam. Ames, Oct. 7, 1877 (Bessey).
On *Helianthus grosse-serratus* Martens. Ames, Sept. 15, 1894 (Combs); Decatur Co., Sept., 1904 (Anderson).
On *Helianthus sp.* Johnson Co., X (X).
On *Helianthus tuberosus*, L. Ames, Sept. 22, 1894 (Combs); Oct. 5, 1891 (Rolfs); Decatur Co., Aug., 1904 and Sept., 1905 (Anderson).
On *Hydrophyllum virginicum*. Ames, Aug. 7, 1899 (Hume); Johnson Co., May 25, 1894 (Glass).
On *Lappula virginica* (L) Greene. Johnson Co., X (X).
On *Leptilon canadense* (L) Britt. Ames, Sept. 22, 1894 (Combs).
On *Parietaria pennsylvanica*, Muhl. Ames, Aug. 19, 1899 (Hume & Hodson).
On *Phlox divaricata* L. Decatur Co., July 12, 1905 (Anderson).
On *Phlox drummondii*, Hook. Ames, Oct., 1892 (Bettinger); 1892 (Wright); Fayette, Sept., 1893 (Fink).
On *Phlox procumbens*. Johnson Co., May, 1889 (Linder).
On *Plantago major*, L. Ames, Oct., 1901 (Lummis); Decatur Co., Oct., 1904 and 1905 (Anderson).
On *Plantago rugelii* Dec. Decatur Co., Oct., 1904 (Anderson).
On *Rudbeckia hirta* L. Johnson Co., X (Macbride).
On *Solidago canandensis*, L. Ames, Sept. 22, 1894 (Combs); *Fayette, 1893 (Fink).
On *Solidago rigida*, L. *Fayette, 1893 (Fink).
On *Solidago serotina* Ait. Iowa City, Oct. 3, 1893 (Bloom).
On *Solidago serotina gigantea* (Ait.), A. Gray. *Fayette, 1893 (Fink).
On *Verbena bracteosa*, Michx. Ames, 1894 (Carver); *Fayette, 1893 (Fink).
On *Verbena hastata*, L. Ames, Aug. 25, 1894 (Combs); Sept., 1896 (Carver); Decatur Co., Aug. 3, 1905 (Anderson); *Fayette, 1893 (Fink); Fremont Co., Aug. 8, 1905 (Anderson); Des Moines, 1895 (Carver); Iowa City, Oct., 1895 (Macbride); Aug. 25, 1893 (Bloom).
On *Verbena stricta*, Vent. Ames, Sept. 8, 1877 (Bessey); Aug. 25, 1893 (Stewart); Sept. 4, 1894 (Combs); Oct. 7, 1901 (Paddock); June 28, 1905 (Anderson); Fremont Co., Aug. 8, 1905 (Anderson); Greenfield, Sept. 18, 1893 (Stewart); Johnson Co. X (X).

On *Verbena urticifolia*, L. Ames, Aug. 30, 1894 (Combs); Oct., 1890 (Blaine); Oct. 19, 1877 (Bessey); 1894 (Carver); Decatur Co., Sept. 3, 1905 (Anderson); *Fayette, 1893 (Fink); Decorah, Oct., 1879 (Holway); Iowa City, Oct. 3, 1893 (Bloom).

On *Verbesina alternifolia* (L.), Britt. Decatur Co., Sept., 1904 and 1905 (Anderson).

On *Vernonia fasciculata*, Michx. Ames, Sept. 1, 1894 (Combs); Sept. 12, 1894 (Stewart); Iowa City, Oct. 7, 1893 (Linder).

On *Vernonia noveboracensis* (L), Willd. Polk City, Aug. 29, 1902 (Pammel); Johnson Co., 1889 (Linder).

This is our most common species of mildew, and behaves somewhat differently on the different host plants. On *Plantago major* the mycelium is more abundant and the perithecia more numerous than on the similar but thinner-leaved *P. rugelii*. On *Aster laevis* I found asci with 2-4 spores although the species is generally easily recognized by its numerous 2-spored asci. During 1904 I looked in vain for perithecia on *Verbena hastata* and *V. urticifolia*, but found none although the conidial stage was very abundant. In 1905 I found an abundance of perithecia on both hosts. I have failed to find perithecia on a number of hosts supposed to be affected with this species and which showed conidia in abundance. Of the host plants here reported under this species I have found the conidial stage on the following in Decatur County but they are not included in the preceding data because no perithecia were found. *Aster salicifolius, A. cordifolius, Carduus altissimus, Hydrophyllum virginicum, Lappula virginica, Solidago canadensis, Verbena bracteosa, Vernonia fasciculata, V. noveboracensis.* Although so common this species is not important economically. Most of the hosts attacked are weeds.

3. *Erysiphe galeopsidis DC.*

Erysiphe galeopsidis, DC. Fink, Blights, etc., of Fayette.

Closely approaches *E. cichoracearum*, but is distinguished by its lobed haustoria and the absence of spores on the living host plant.

On *Mint*, St. Francis river, July 14, 1897 (X).

On *Scutellaria lateriflora*, L. Ames, Oct. 12, 1878 (Bessey); Fayette, 1893 (Fink); Iowa City, Oct. 28, 1893 (Bloom).

On *Scutellaria galericulata* Ames, 1899 (Pammel).

On *Stachys palustris*, L. Ames, Oct. 5, 1898 (Ball).

On *Stachys sp.* Johnson Co., X (X).

On *Teucrium canadense* L. Johnson Co., X (X).

It is very doubtful if this form is entitled to rank as a distinct species. It has been ascertained that certain forms of *E. cichoracearum* do not form spores on the living host plant and that the

same species on certain hosts shows a tendency to form lobed haustoria.

4. *Erysiphe graminis* DC.

Erysiphe graminis DC. Bessey, Prel. List Ames Flora; Hitchcock; partial list Iowa Powdery Mildews; Fink, Blights, etc., of Fayette.

Usually epiphyllous; mycelium more or less persistent; perithecia large, 135-280 micra in diameter, scattered or gregarious, more or less immersed in the persistent mycelium, cells obscure; appendages rudimentary, very short, pale brown; asci 9-30, pedicellate, 70-108x24-40 micra; spores 8 (rarely 4); 20-23x 10-13 micra, seldom produced on the living host plant.

On *Cinna arundinacea*, L. Fayette, 1893 (Fink).

On *Poa pratensis*, L. *Ames, Aug., 1886 (Hitchcock); Decatur Co., Oct. 4, 1904 (Anderson); *Fayette, 1893 (Fink); Johnson Co., May 3, 1894 (X).

This species is quite common on *Poa pratensis*, but the perithecia are seldom found. They appear to be formed early.

Erysiphe taurica Lev.

Mycelium often covering the whole plant, usually persistent, effused, densely compacted, tomentose, membranaceous or crustaceous; perithecia usually immersed in the persistent mycelium, large, 135-240 micra in diameter, soon becoming concave; cells obscure; appendages usually numerous, densely interwoven, rather short and vaguely branched, sometimes very short or even obsolete; asci 7-38, pedicellate, large, 75-110x28-40 micra; spores 2, large, 28-40x14-22 micra.

On *Heliopsis scabra* Dunal. Decatur Co., Aug.-Oct., 1904 and 1905 (Anderson); Ringgold Co., Oct. 10, 1905 (Anderson).

Heretofore this has been considered as an old world species. Salmon, in his monograph of the Erysiphaceae, gives the distribution of this species as the continent of Europe (France, Spain, Italy, Greece, Germany, Austria-Hungary, Russia), Algeria in Africa, and Turkey, Syria, Persia, Turkestan, and India in Asia. It seems somewhat strange that this species should now be found in the middle of the United States, but I can refer the form under consideration to no other species as it agrees in every important detail with the description given for *E. taurica*.

In August, 1904, I first collected this species but on examination I found that the perithecia had not developed asci. I collected at intervals during the fall but not until very late in the season could I find traces of asci. In 1905 I found asci somewhat earlier but have been unable to find spores without soaking in water for 24-48 hours.

During the autumns of 1904 and 1905 nearly every plant of *Heliopsis scabra* seen by the writer in Decatur and Ringgold counties, Iowa, and Harrison County, Missouri, presented a white

or hoary appearance, from the presence of this mildew. It had not been observed previously and the *Heliopsis scabra* seen in Fremont County and eastern Nebraska in 1905 was not affected.

E. M. Freeman in Minnesota Botanical Studies XXIV, reports *Erysiphe cichoracearum* on *Heliopsis scabra.* It is quite probable that this was the species under consideration.

MICROSPHAERA Lev.

Perithecia globose to globose depressed; asci several, 2-8 spored; appendages free from the mycelium; more or less dichotomously branched at the apex.

Key to Iowa Species of Microsphaera.

Tips of appendages recurved when mature.
Appendages short, ⅓-2½ times the diameter of the perithecium....1. *M. alni*
Appendages long, 2½-8 times the diameter of the perithecium.
Apex much branched, ornate, spores 22-26x12-15 micra....3. *M. alni extensa*
Apex less branched, spores 18-23x9-13 micra..............2. *M. alni vaccinii*
Tips of appendages not recurved when mature.
Appendages colored......................................6. *M. russellii*
Appendages hyaline or nearly so:
Appendages long, 2-7 times the diameter of the perithecium, contorted and angularly bent, branching irregular and lax............7. *M. euphorbiae*
Appendages, 2-4 times the diameter of the perithecium, branching lax...5. *M. diffusa*
Appendages, 1-2 times the diameter of the perithecium, branching close and regular ....4. *M. grossulariae*

Microsphaera alni (Wallr.) Wint.

Microsphaera alni (Wallr.), Wint. Fink, Blights, etc., of Fayette.
Microsphaera abbreviata Peck. Bessey, The Erysiphei.
Microsphaera densissima (Schwein.), C. & P., Bessey, The Erysiphei.
Microsphaera friessi Lev. Bessey, Prel. List Ames Flora; Hitchcock, Partial List Iowa Powdery Mildews.
Microsphaera hedwigii Lev. Bessey, The Erysiphei; Hitchcock, Partial List Iowa Powdery Mildews.
Microsphaera menispermi E. C. Howe. Bessey, The Erysiphei.
Microsphaera platani E. C. Howe. Bessey, The Erysiphei.
Microsphaera pulchra Cook & Peck. Bessey, The Erysiphei.
Microsphaera ravenellii Berk. Bessey, The Erysiphei.
Microsphaera semitosta Berk & Curt. Bessey, The Erysiphei.
Microsphaera quercina (Schwein.), Burr, in part. Fink, Blights, etc., of Fayette.

Amphigenous; mycelium variable, evanescent or persistent, sometimes forming definite patches; perithecia scattered or gregarious, 66-110 micra in diameter, sometimes larger; cells 10-15 micra wide; appendages 4-26, ⅓-2½ times the diameter of the perithecium, rigid, sometimes colored at the base; apex variously but closely, 3-6 times, dichotomously branched; tips recurved; asci 3-8, 42-70x32-50 micra; spores, 4-8, 18-23x10-12 micra.

On *Alnus rugosa* (Du Roi), K. Koch, Jones Co., Aug., 1895 (Macbride).
On *Carpinus caroliniana* Walt., *Fayette, 1893 (Fink).
On *Ceanothus americanus* L. Johnson Co. X (X).
On *Cornus candidissima* Marsh. Muscatine, Oct. 21, 1893 (Bloom).
On *Corylus americana* L. Ames, Sept. 2 and 14, 1878 (Bessey); Sept. 8, 1894 (Stewart & Stewart); Decatur Co., Oct., 1904 (Anderson); *Fayette, 1893 (Fink); Johnson Co., Sept. 29, 1886 (Macbride).
On *Euonymons autopurpurens* Jacq. Fayette, Sept., 1893 (Fink).
On *Flowering pea.* Johnson Co., Sept., 1889 (Bloom).
On *Juglans regia.* Iowa City, Sept., 1888 (Macbride).
On *Lathyrus odoratus* L. Ames, Oct., 1902 (Fawcett); Johnson Co., Aug., 1892 (Macbride); Corydon, Nov. 6, 1900 (Stromsten).
On *Lathyrus palustris,* L. Johnson Co., X (X).
On *Louicera sullivantii* A. Gray. Decorah, Aug., 1879 (Holway); *Fayette, 1893 (Fink); Fremont Co., Aug. 7, 1905 (Anderson).
On *Lonicera sp.* Ames, Oct. 9, 1892 (Carver); Forest City, X (X); Decatur Co., Oct., 1905 (Anderson).
On *Menispermun canadense* L. *Holway in E. & E.. N. A. Pyrenomycetes.
On *Ostrya virginiana* (Mill.), Willd., Decatur Co., Oct. 28, 1905 (Anderson).
On *Quercus macrocarpa* Michx. Ames, Oct. 9, 1894 (Combs.)
On *Quercus robur.* Ames, Oct., 1893 (Carver).
On *Quercus rubra* L. Ames, Sept. 14, 1878 (Bessey); Oct. 20, 1882 (Osborn); Boone Co., Aug. 19, 1903 (Pammel & Buchanan); Decatur Co., Nov., 1904 (Anderson); Iowa City, Sept. 9, 1900 (Shinnek); Oct. 7, 1898 (Bloom); Muscatine, Oct. 20, 1900 (X).
On *Quercus velutina* Lam. Johnson Co., Oct., 1886 (Macbride).
On *Syringa vulgaris* L. Ames, 1878 (Bessey); 1891 (Raymond); Oct. 9, 1892 (Carver); Sept. 4, 1894 (Coombs); Sept. 10, 1894 (Stewart & Stewart); July 22, 1898 (Carver); Oct. 14, 1901 (Lummis); Decatur Co., Nov. 7, 1905 (Anderson); Fayette, Sept., 1893 (Fink); Iowa City, Oct. 12, 1886 (Macbride); Jordan, July 30, 1903 (Buchanan).
On *Ulmus americana* L. *Fayette, 1893 (Fink).
On *Vibernum lentago* L. Decorah, Sept. 9, 1879 (Holway); *Fayette, 1893 (Fink); Johnson Co., X (X).
On *Vicia sp.* Johnson Co., Aug. 12, 1884 (Macbride).

This is a common and very variable species attacking a great variety of host plants. In the State University herbarium is a specimen on *Platanus occidentalis* collected in October, 1901, in Illinois opposite Muscatine. This species does not appear to be as destructive as some others but injures the host to some extent, often quite seriously.

2. *Microsphaera alni vaccinii* (Schwein.) Salmon.

Microsphaera elevata, Burr. Bessey, The Erysiphei; Hitchcock, Partial List Iowa Powdery Mildews.

Generally epiphyllous; mycelium persistent or sometimes evanescent; perithecia variable in size, 70-145 micra in diameter, cells 10-20 micra wide; ap-

pendages 4-22, 2½-8 times the diameter of the perithecium, delicate, hyaline or occasionally brown at the base, apex 2-4 times dichotomously branched, branches variable; tips recurved; asci 2-16, 45-72x28-38 micra, spores 4-6, 18-22x10-13 micra.

On *Catalpa catalpa* (L.), Karst, Johnson Co., Sept. 25, 1886 (Macbride).

On *Catalpa speciosa* Warder. Decatur Co., 1904 and 1905 (Anderson); *Iowa City, Oct., 1886 (Hitchcock); Scott Co., Sept. 1, 1897 (Macbride).

This species is occasionally quite destructive, causing a dying and premature dropping of the leaves, thereby greatly weakening the tree.

3. *Microsphaera alni extensa* (Cooke & Peck) Salmon.

Microsphaera extensa Cooke & Peck. Bessey, The Erysiphei, and Prel. List Ames Flora; Hitchcock, Partial List Iowa Powdery Mildews.

Microsphaera quercina (Schwein.), Burr, in part. Fink, Blights, etc., of Fayette.

Epiphyllous; mycelium persistent; perithecia gregarious, 90-140 micra in diameter, cells 10-20 micra wide; appendages 8-19, 2½-6 times the diameter of the perithecium, apex 3-5 times dichotomously forked; tips regularly recurved; asci 3-8, short pedicellate, 58-72x34-45 micra; spores, 4-8, 22-26x12-15 micra.

On *Quercus alba* L. *Fayette, 1893 (Fink).

On *Quercus prinoides* Willd. Decatur Co., Oct., 1904 (Anderson).

On *Quercus rubra* L. *Fayette, 1893 (Fink).

This variety seems to intergrade with the type of the species and it is difficult to draw the line between them. Some of the specimens on *Quercus* referred to under *M. alni* may belong here and the two specimens from Fayette referred to here may belong under *M. alni.* Forms on *Q. rubra* from Decatur County are clearly *M. alni* while specimens on *Q. prinoides* gathered about the same time are typical of the variety extensa. It is not very destructive.

4. *Microsphaera grossulariae* (Wallr.) Lev.

Microsphaera grossulariae (Wallr.), Lev. Bessey, The Erysiphei; Fink, Blights, etc., of Fayette.

Microsphaera van bruntae Ger. Bessey, The Erysiphei.

Epiphyllous or amphigenous; mycelium evanescent or subpersistent, perithecia scattered to densely gregarious, 65-130 micra in diameter, cells 14-20 micra wide; appendages 5-22, 1-1¾ times the diameter of the perithecium, colorless, apex 4-5 times closely dichotomously branched, ultimate branches forming a narrow fork, tips not recurved; asci 4-10, very short stalked, 46-62x28-38 micra; spores 4-6; very rarely only 3, 20-28x2-16 micra.

On *Sambucus canadensis* L. Fayette, Oct., 1893 (Fink); Johnson Co., Oct., 1889 (Linder).

In Europe this species attacks the cultivated gooseberry and is sometimes quite troublesome. In America it sometimes attacks

other species of *Ribes* and *Sambucus*. The American gooseberry mildew is *Sphaerotheca mors-uvae*. *M. grossulariae* is seemingly quite rare in Iowa.

5. *Microsphaera diffusa*, Cooke & Peck.

Microsphaera diffusa Cooke & Peck. Bessey, The Erysiphei.

Microsphaera symphoricarpi E. C. Howe. Bessey, The Erysiphei, and Prel. List, Ames Flora; Hitchcock; Partial List Iowa Powdery Mildews.

Amphigenous; mycelium persistent or somewhat evanescent; perithecia scattered or gregarious, variable, 55-126 micra in diameter, cells 10-20 micra wide; appendages 4-30 or rarely more, 1½-7 times the diameter of the perithecium, colorless or pale brown toward the base apex, 3-5 times dichotomously branched, tips not recurved, branches of the higher orders often appearing lateral; asci 4-9, 46-60x28-30 micra, short pedicellate; spores 3-6, 18-22x9-11 micra.

On *Meibomia canadensis* (L.) Kuntze. Decatur Co., Oct., 1904 and 1905 (Anderson); Fremont Co., Aug. 8, 1905 (Anderson); Ringgold Co., Oct. 7, 1905 (Anderson).

On *Meibomia sessilifolia* (Torr.), Kuntze, Ames, Sept. 14, 1898.

On *Symphoricarpos symphoricarpos* (L.) MacM. Ames, Sept. 7, 1882 (Bessey); Oct. 4, 1882 (Bessey); Aug., 1886 (Hitchcock); Decatur Co., Sept., 1904 and 1905 (Anderson); Corydon, Nov. 5, 1900 (Stromsten); Fremont Co., Aug. 7, 1905 (Anderson); Johnson Co., Oct., 1882 (Hitchcock).

The form on Meibomia has generally been considered distinct from that on *Symphoricarpos* but there does not appear to be sufficient difference to justify such separation.

In the southern part of the state this species is very common both on *Meibomia canadensis* and *Symphoricarpos vulgaris*. In summer *Symphoricarpos* sometimes presents a whitish appearance from the abundance of the conidial stage of this species.

6. *Microsphaera russellii* Clinton.

Microsphaera russellii Clinton. Bessey, The Erysiphei and Prel. List Ames Flora; Hitchcock, Partial List Iowa Powdery Mildews; Fink, Blights, etc., of Fayette.

Amphigenous; mycelium inconspicuous; perithecia scattered, 70-118 micra in diameter, cells 6-14 micra wide; appendages 5-14, 3-7 times the diameter of the perithecium, flaccid, colored nearly to the apex, septate, apex 2-4 times dichotomously branched, branching irregular and lax, tips not recurved; asci 4-9, short pedicellate, 42-56x24-32 micra; spores 3-5, 18-22x10-12 micra.

On *Oxalis stricta*, L. Ames, Oct. 17, 1878 (Bessey); Decorah, Oct. 19, 1878 (Holway); Decatur Co., Oct., 1905 (Anderson); Fayette, Oct., 1892 (Fink); Iowa City, Oct., 1886 (Hitchcock).

In this species the appendages are very slow in arriving at maturity.

Microsphaera euphorbiae (Peck), Berk & Curt.

Erysiphe euphorbiae Peck. Bessey, The Erysiphei.

Microsphaera euphorbia (Peck), Berk & Curt. Fink, Blights, etc., of Fayette.

Amphigenous; mycelium subpersistent or sometimes evanescent; perithecia 85-145 micra in diameter, rarely larger, cells 10-15 micra wide, appendages 7-28, 2½-8 times the diameter of the perithecium, flexuose, often angularly bent, colorless, aseptate, apex 3-4 times dichotomously branched, branching irregular and lax, tips straight or recurved; asci 4-13, rarely more; short pedicellate, 48-66x26-33 micra; spores usually 4 (3-6), 19-21x10-12 micra.

On *Euphorbia corollata,* L. Decatur Co., Oct., 1904 and 1905 (Anderson); Decorah, Sept., 1879 (Holway); *Fayette, 1893 (Fink); Ringgold Co., Oct. 7, 1905 (Anderson).

On *Euphorbia marginata* Pursh. Johnson Co., 1888 (Macbride).

As in some other species of *Microsphaera* the appendages are very slow in arriving at maturity, hence it is often collected with the appendages not yet branched.

In August, 1905, I found this species in abundance on *Euphorbia marginata* in Cass County, Nebraska, but could find none on the east side of the Missouri River in Fremont County although the host was very abundant.

Uncinula Lev.

Perithecium containing several asci, asci 2-8 spored; appendages free from the mycelium, uncinate or coiled at the apex.

Key to Iowa Species of Uncinula.

Appendages colored ....2. *U. necator*
Appendages hyaline or nearly so.
  Asci 2 spored..5. *U. macrospora*
  Asci 4-8 spored.
    Appendages delicate, narrow, 3-4 micra wide, asci 4-7 spored.
      Appendages 50-160, ½-¾ times the diameter of the perithecium...... ....4. *U. parvula*
      Appendages 24-46, 1¼-2 times the diameter of the perithecium........ ....7. U. *geniculata*
    Appendages stouter.
      Appendages thick walled, refractive at base............6. *U. clintoni*
      Appendages thin walled.
        Asci 4-6 spored..1. *U. salicis*
        Asci 7-8 spored..3. *U. circinata*

1. *Uncinula salicis* (DC.) Wint.

Uncinula adunca, Lev. Bessey, The Erysiphei, and Prel. List, Ames Flora; Hitchcock, Partial List Iowa Powdery Mildews.

Uncinula heliciformis E. C. Howe. Hitchcock, Partial List Iowa Powdery Mildews.

Uncinula salicis (DC.), Wint. Fink, Blights, etc., of Fayette.

Amphigenous; mycelium evanescent or persistent; perithecia 90-175 micra in diameter, cells 10-15 micra wide; appendages usually numerous or crowded, 100-

150, sometimes less, ¾-2½ times the diameter of the perithecium, simple, hyaline, slightly enlarged upward; asci 8-14, rarely less, 55-80x30-40 micra; spores 4-6, 20-26x10-15 micra.

On *Populus deltoides*, Marsh. Johnson Co., X (X).

On *Populus grandidentata* Michx. Columbus Jc., Aug., 1899 (Pammel); Johnson Co., X (Macbride).

On *Populus tremuloides*, Michx. *Iowa City, Oct., 1886 (Macbride).

On *Salix amygdaloides* Anders., Ames, Aug. 30, 1894 (Combs).

On *Salix discolor*, Muhl. Ames, Aug. 15, 1898 (Ball); Greenfield, Sept. 18, 1893 (Stewart); Johnson Co., Oct. 21, 1893 (Shimek).

On *Salix humilis*, Marsh. Ames, Sept., 1899 (Pammel).

On *Salix sp.* Ames, Oct. 12, 1878 (Bessey); *July, 1886 (Hitchcock); Decorah, Sept., 1879 (Holway); Fayette, Sept., 1893 (Fink); Johnson Co., Aug., 1886 (Hitchcock); Mason City, Sept., 1900 (Shimek); Rock Rapids, Aug. 5, 1896 (Shimek).

This is a very variable and widely distributed species. The forms on *Populus* and *Salix* differ somewhat but not enough to justify separation.

Uncinula necator (Schwein.) Burr.

Uncinula americana, E. C. Howe. Bessey, Prel. List Ames Flora.

Uncinula ampelopsidis. Peck. Bessey, Prel. List Ames Flora, Hitchcock, Partial List Iowa Powdery Mildews.

Uncinula necator (Schwein.), Burr. Fink, Blights, etc., of Fayette.

Amphigenous, with perithecia usually epiphyllous, sometimes occurring on the inflorescence; mycellium evanescent to subpersistent; perithecia more or less scattered, 70-128 micra in diameter, cells rather irregular in shape, 10-20 micra wide, appendages 7-32, 1-4 times the diameter of the perithecium, septate, the lower half colored; apex more or less helicoid when mature; asci 4-6, rarely more, 50-60x30-40 micra; spores 4-7, 18-25x10-12 micra.

On *Parthenocissus quinquefolia* (L), Planch. Ames, Sept. 11, 1882 (Bessey); Aug. 17, 1899 (Hume); Decatur Co., Sept. and Oct., 1904 and 1905 (Anderson); Decorah, Sept., 1879 (Holway); Johnson Co., Oct. 23, 1886 (Macbride); Ringgold Co., Oct. 7, 1905 (Anderson).

On *Vitis cordifolia* Michx. *Fayette, 1893 (Fink).

On *Vitis labrusca*, L. Ames, Aug., 1891 (Pammel); Oct. 30, 1891 (Rolfs); Oct., 1892 (Bettinger); Decatur Co., Oct., 1905 (Anderson).

On *Vitis sp.* Ames, Sept., 1889 (X); Sept., 1890 (Pammel); Sept. 12, 1894 (Combs); Fayette, Oct., 1893 (Fink).

This is the powdery mildew of the grape and is to be distinguished from the downy mildew, *Peronospora viticola*. In Iowa it does not appear to be as destructive on the grape as it is on the Virginia creeper *(Parthenocissus quinquefolia)*. On the latter host it is frequently quite destructive, as it also appears to be on the grape in some regions. In Iowa so far as the writer's observation indicates, the *Peronospora* is more destructive than the Uncinula.

Sulphur and Bordeaux mixture are used as remedies against the present species.

Uncinula circinata Cooke & Peck.

See Plate II.

Uncinula circinata, Cooke & Peck. Bessey, Prel. List, Ames Flora; Hitchcock, Partial List Iowa Powdery Mildews; Fink, Blights, etc., of Fayette.

Hypophyllous; mycelium usually evanescent; perithecia usually scattered, 160-225 micra in diameter, rarely smaller; cells irregular, 10-14 micra wide; appendages very numerous, usually crowded, their length rather less than the diameter of the perithecium, simple, hyaline, apex simply uncinate; asci 9-26, 68-86x29-40 micra; spores 8, sometimes only 7, 18-22x10-14 micra.

On *Acer saccharinum,* L. Ames, Oct., 1894 (Carver); *Belle Plaine, Sept., 1886 (Hitchcock); Decatur Co., Oct. 28, 1905 (Anderson); Decorah, Oct., 1879 (Holway); Iowa City, Oct. 7, 1893 (Bloom).

On *Acer saccharum,* Marsh. *Fayette, Sept., 1893 (Fink).

A very beautiful species under the microscope. A specimen labeled *U. circinata* on *Acer saccharum* in Prof. Fink's herbarium proved to be *Phyllactinia corylea.*

Uncinula parvula Cooke & Peck.

Amphigenous; mycelium evanescent; perithecia usually hypophyllous, scattered, 86-122 micra in diameter, cells about 10 micra wide; appendages numerous 50-160, ½-¾ times the diameter of the perithecium, simple, hyaline, apex simply uncinate; asci, 5-8, 50-64x34-38 micra; spores 4-7, usually 6, 20-24x10-12 micra. On *Celtis occidentalis* L. Ames, Sept. 15, 1878 (Bessey).

Uncinula macrospora Peck.

Uncinula intermedia Berk. & Curt. Bessey, The Erysiphei.

Uncinula macrospora Peck. Bessey, The Erysiphei; Hitchcock, Partial List Iowa Powdery Mildews; Fink, Blights, etc., of Fayette.

Amphigenous; mycelium evanescent or subpersistent, often forming circumscribed patches on the upper surface of the leaf; perithecia gregarious or scattered, 95-165 micra in diameter; cells about 10 micra wide; appendages 50-130 or more, ⅓-1 times the diameter of the perithecium; colorless; aseptate; apex simply uncinate, rarely subhelicoid; asci 8-14 or more; often curved, 54-65x 29-35 micra; spores 2, 30x15-18 micra.

On *Ulmus americana* L. *Cedar Rapids, Sept., 1886 (Hitchcock); Decatur Co., Oct., 1905 (Anderson); Decorah, Sept., 1879 (Holway); Fayette, Sept., 1894 (Fink); Johnson Co., Sept., 1885 (Macbride).

On *Ulmus racemosa* Thomas. Decatur Co., Oct. 28, 1905 (Anderson).

On *Ulmus americana* I have found the perithecia evenly distributed over the under surface of the leaf with the mycelium completely evanescent and I have also found it with mycelium subpersistent in circumscribed patches on the upper surface of the leaf.

On *Ulmus racemosa* all I have found has been in circumscribed patches on the upper surface of the leaf. These patches are often very conspicuous.

Uncinula clintoni Peck.

Uncinula clintoni Peck. Hitchcock, Partial List Iowa Powdery Mildews; Fink, Blights, etc., of Fayette.

Hypophyllous or amphigenous, mycelium usually more or less evanescent; perithecia gregarious or scattered, 80-130 micra in diameter, cells irregular in shape, 10-20 micra wide; appendages 10-35, 1-2½ times the diameter of the perithecium, hyaline or somewhat colored at base; apex clavate uncinate; asci 4-10, very short stalked, 40-62x34-40 micra; spores 3-7, 20-27x10-13 micra.

On *Tilia americana* L. Ames, Sept. 22, 1878 (Bessey); 1878 (Thomas); Sept., 1892 (Bettinger); *Cedar Rapids, Sept., 1886 (Hitchcock); Decorah, Aug., 1879 (Holway); *Fayette, 1893 (Fink); Johnson Co., Sept. 14, 1886 (Macbride); Jones Co., Aug., 1895 (Macbride); Muscatine, Oct. 20, 1900 (Stromsten).

Uncinula geniculata Gerard.

Epiphyllous; mycelium thin; forming definite patches or more or less effused, sometimes evanescent; perithecia subgregarious or scattered, 90-120 micra in diameter, cells rather irregular, 10-15 micra wide; appendages 24-46, 1¼-2 times the diameter of the perithecium, some usually abruptly bent or geniculate, hyaline, aseptate, apex simply uncinate; asci 5-8; very short pedicellate, 48-56x34-38 micra; spores 4-6, 22x12 micra.

On *Morus rubra* L. Decatur Co., Oct. 28, 1905 (Anderson).

This species is very inconspicuous and may be much more common than would be indicated by the fact that it is not often collected.

PHYLLACTINIA Lev.

Perithecia large; asci many; 2, rarely 3-spored, appendages hyaline, free from the mycelium, acicular or rarely flexuously bent, acute at tip with a bulbous base; apex of perithecium provided with outgrowths from the epidermal cells. This genus is often separated from the others as a subfamily (Phyllactinicae). This distinction is based on the fact that the mycelium does not form haustoria in the ordinary manner, but sends special branches into the stomata of the host, each of these branches giving rise to an haustorium which penetrates the surrounding tissue.

Key to Iowa Species of Phyllactinia.

Appendages undivided ....1. *P. corylea*
Appendages divided ....2. *P. corylea tomentosa*

Phyllactinia corylea (Pers.) Karst.

Phyllactinia condollei Lev. Bessey, The Erysiphei.

Phyllactinia guttata (Wallr.), Lev. Bessey, The Erysiphei.

Phyllactinia suffulta (Rebent.), Sacc. Bessey, Prel. List. Ames Flora; Hitchcock, Partial List Iowa Powdery Mildews; Fink, Blights, etc., of Fayette.

Usually hypophyllous; mycelium persistent or scant and evanescent; perithecia usually scattered, 140-270 micra in diameter or larger, cells obscure, 15-20 micra wide; appendages 5-18 or more, 1-3 times the diameter of the perithecium, acicular, rigid, hyaline, aseptate, swollen at the base into a hollow bulb, asci 5-45, 60-105x20-40 micra, rarely larger, pedicellate, spores generally 2, rarely 3, 30-42x16-25 micra, when 3 smaller.

On *Acer saccharum* Marsh. Fayette (Fink).
On *Betula papyrifera* Marsh. *Fayette, 1893 (Fink).
On *Cornus florida* L. *Fayette, 1893 (Fink).
On *Cornus stolonifera* Michx. Fayette, Sept., 1893 (Fink).
On *Corylus americana*, L. *Fayette, 1893 (Fink); Johnson Co., Sept. 25, 1886 (Macbride); Sept. 19, 1899 (Shimek); *Oct., 1886 (Hitchcock).
On *Crataegus coccinea* L. Johnson Co., Oct., 1894 (X).
On *Crataegus sp.* *Fayette, 1893 (Fink).
On *Crataegus tomentosa* L. Ames, Oct. 14, 1901.
On *Celastrus scandens* L. Johnson Co., X (X).
On *Fraxinus lanceolata* Berk. Story City, Aug. 27, 1903 (Buchanan).
On *Fraxinus sp.* *Fayette, 1893 (Fink).
On *Meibomia canadense* (L.), Kuntze. Johnson Co., X (X).
On *Meibomia grandiflora* (Walt.), Kuntze. *Fayette, 1893 (Fink).
On *Ostrya virginiana* (Mill.) Willd. Ames, 1877 (Bessey); Decatur Co., Oct. 28, 1905 (Anderson); Iowa City, Oct. 6, 1900 (Stromsten); Muscatine, Oct. 20, 1900 (Stromsten).
On *Quercus palustris* DuRoi. Johnson Co., Nov., 1886 (Macbride).
On *Quercus rubra* L. Johnson Co., Oct. 12, 1886 (X).
On *Quercus velutina* Lam. Johnson Co., 1886 (Macbride).
On *Ulmus americana* L. *Fayette, 1893 (Fink).
On *Ulmus racemosa* Thomas. Decatur Co., Oct. 28, 1905 (Anderson).
On *Xanthoxylum americanum* Mill. Ames, Sept. 15, 1878 (Bessey); Fayette, Sept., 1894 (Fink).

This species seems to be very common in the eastern part of the state but is not so plentiful in the southwestern part. I have found it rarely in Decatur County. It probably does not grow on herbaceous plants but perithecia are often found there. The apical outgrowths serve to attach the perithecium to the substratum and by this means stray perithecia may seem to be firmly attached where they did not originate.

Phyllactinia corylea tomentosa, Macbride & Peck, Var., Nov.

See Plate I.

Hypophyllous; mycelium persistent; perithecia as in *P. corylea;* appendages 2-3 times the diameter of the perithecium; divided down to the bulbous base, the divisions flexuously bent in graceful curves, hyaline, aseptate.
On *Quercus velutina*, Lam. Johnson Co., 1886 (Macbride).

In the herbarium of the State University were a few specimens labeled *Phyllactinia suffulta* var. *tomentosa.* On inquiry Prof.

Macbride informed the writer that he collected the same during the fall of 1886 at which time there was an abundance. It covered the entire north side of a tree 40 feet high. A quantity was collected but most of it was afterward found missing. No special effort has since been made to collect it.

The variety is based on the appendages which are markedly different from those of the type. Profs. Macbride and Peck agreed upon the name *Phyllactinia suffulta tomentosa* for the variety. It seems that *corylea* rather than *suffulta* is the name that should be applied to the species and is so published here.

The occurrence of this variety and the circumstances under which it was found are rather remarkable. Its taxonomic position is a puzzle. The appendages are so different from those of the typical *P. corylea* that it might be considered a distinct species if it could be shown that these differences were constant. On the other hand it may simply be a sport due to some peculiarities of host plant and season. Several facts seem to lend color to the latter view.

HOST INDEX.

Abbreviations used: E., Erysiphe; M., Microsphaera; Ph., Phyllactinia; Po., Podosphaera; S., Sphaerotheca; U., Uncinula.

For those marked ? see pages.

Acer saccharinum L. .... *U. circinata*
Acer saccharinum Wang. See *A. saccharinum* Marsh.
Acer saccharum Marsh. .... *U. circinata*
Acer dasycarpum Ehrh. See A. *saccharinum* L.
Actinomeris squarrosa Nutt. See *Verbesina alternifolia.*
Adicea pumila (L.) Raf. .... *E. cichoracearum*
Agrimonia eupatoria L. See *A. hirsuta.*
Agrimonia hirsuta (Muhl.) Bicknell .... *S. humuli*
Alnus rugosa (DuRoi) K. Koch .... *M. alni*
Alnus serrulata Willd. See *A. rugosa.*
Ambrosia artemisiaefolia L. .... *E. cichoracearum*
Ambrosia psilostachya DC. .... *E. cichoracearum*
Ambrosia trifida L. .... *E. cichoracearum*
Ambrosia trifida integrifolia (Muhl.) T. & G. .... *E. cichoracearum*
Ampelopsis quinquefolia Michx. See *Parthenocissus quinquefolia.*
Amphicarpa pitcheri T. & G. See *Falcata pitcheri.*
Anemone canadensis L. .... *E. polygoni*
Anemone pennsylvanica L. See *A. canadensis.*
Anemone sp. .... *E. polygoni*
Anemone virginiana L. .... *E. polygoni*
Anemonella thalictroides Spach. See *Syndesmon thalictroides.*
Artemisia biennis Willd. .... *E. cichoracearum*
Artemisia gnaphaloides Nutt. .... E. cichoracearum
Artemisia serrata Nutt. .... E. cichoracearum

Asclepias tuberosa L..?
Astragalus carolinianus L....................................*E. polygoni*
Astragalus canadensis L. See *A. carolinianus.*
Aster carneus T. & G. See *A. salicifolius.*
Aster cordifolius L....................................*E. cichoracearum*
Aster laevis L..*E. cichoracearum*
Aster multiflorus Ait..?
Aster purpuratus Nees...................................*E. cichoracearum*
Aster sagittifolius Willd...............................*E. cichoracearum*
Aster salicifolius Lam..................................*E. cichoracearum*
Betula papyrifera Marsh.......................................*Ph. corylea*
Bidens laevis (L.) B. S. P...........................*S. humuli fulginea*
Bidens frondosa L....................................*S. humuli fulginea*
Bidens involucrata (Nutt.) Britton...................*S. humuli fulginea*
Bidens sp ....*S. humuli fulginea*
Brassica nigra (L.) Koch......................................*E. polygoni*
Brassica sp ....?
Brunella vulgaris. See *Prunella vulgaris.*
Cacalia tuberosa Nutt. See *Prunella vulgaris.*
Carduus altissimus L....................................*E. cichoracearum*
Carduus discolor (Muhl.) Nutt...........................*E. cichoracearum*
Carpinus caroliniana Walt...*M. alni*
Catalpa bignonoides Walt. See *C. catalpa.*
Catalpa catalpa (L.) Karst...............................*M. alni vaccinii*
Catalpa speciosa Warder..................................*M. alni vaccinii*
Ceanothus americanus L..*M. alni*
Celastrus scandens L...*Ph. corylea*
Celtis occidentalis L........................*S. phytoptophila—U. parvula*
Cinna arundinacea L..*E. graminis*
Chrysanthemum sp ....?
Clematis virginiana L..*E. polygoni*
Cnicus altissimus Willd. See *Carduus altissimus.*
Cnicus altissimus discolor A. Gray. See *carduus discolor.*
Cnicus discolor Muhl. See *carduus discolor.*
Coreopsis involucrata Nutt. See Bidens *involucrata.*
Cornus florida L...*Ph. corylea*
Cornus candidissima Marsh...*M. alni*
Cornus stolonifera Michx.......................................*Ph. corylea*
Cornus paniculata L'Her. See *C. candidissima.*
Corylus americana L...............................*M. alni—Ph. corylea*
Cosmos bipinnatus ....*E. cichoracearum*
Crataegus coccinea L.........................*Po. oxycanthae—Ph. corylea*
Crataegus punctata Jacq.....................................*Po. oxycanthae*
Crataegus sp.................................*Po. oxycanthae—Ph. corylea*
Crataegus tomentosa L........................*Po. oxycanthae—Ph. corylea*
Cucumis sativa L...?
Diospyros virginiana L...?
Desmodium canadense DC. See *Meibomia canadensis.*
Desmodium acuminatum DC. See *Meibomia grandiflora.*

Desmodium sessilifolium T. & G. See *Meibomia sessilifolia.*
Echinospermum virginicum Lehm. See *Lappula virginica.*
Epilobium coloratum Muhl...*S. humuli*
Erechitites hieracifolia (L.) Raf..........................*S. humuli fulginea*
Erigeron canadensis L. See *Leptilon canadense.*
Euonymous atropurpureus Jacq.......................................*M. alni*
Eupatorium perfoliatum L...............................*E. cichoracearum*
Eupatorium purpureum L...............................*E. cichoracearum*
Euphorbia carollata L....................................*M. euphorbiae*
Euphorbia marginata Pursh...............................*M. euphorbiae*
Falcata pitcheri (T. & G.) Kuntze............................*E. polygoni*
Fraxinus lanceolata Berk....................................*Ph. corylea*
Fraxinus sp ....*Ph. corylea*
Fraxinus viridis Michx. See *F. lanceolata.*
Flowering pea ....*M. alni*
Galium circaezans Michx...............................*E. cichoracearum*
Geranium maculatum L...*E. polygoni*
Grindelia squarrosa (Pursh) Dunal......................................?
Geum virginicum L..?
Helenium autumnale L...................................*E. cichoracearum*
Helianthus annuus L.....................................*E. cichoracearum*
Helianthus doronicoides Lam..........................*E. cichoracearum*
Helianthus grosse-serratus Martens...................*E. cichoracearum*
Helianthus sp..*E. cichoracearum*
Helianthus tuberosus L...................................*E. cichoracearum*
Heliopsis scabra Dunal...*E. taurica*
Hydrophyllum virginicum ....*E. cichoracearum*
Juglans regia ....*M. alni*
Lactuca canadensis L...?
Lactuca floridana (L) Gaertn...?
Lactuca sagittifolia Ell..?
Lappula virginiana (L.) Greene........................*E. cichoracearum*
Lathyrus odoratus L...*M. alni*
Lathyrus palustris L..*M. alni*
Leptandra virginica (L.) Nutt..........................*S. humuli fulginea*
Leptilon canadense (L.) Britton.......*S. humuli fulginea—E. cichoracearum*
Lonicera sp ....*M. alni*
Lonicera sullivantii A. Gray..*M. alni*
Malus malus (L.) Britton...................................*Po. leucotricha*
Meibomia canadensis (L.) Kuntze..................*M. diffusa—Ph. corylea*
Meibomia grandiflora (Walt.) Kuntze.......................*Ph. corylea*
Meibomia sessilifolia (Torr.) Kuntze........................*M. diffusa*
Menispermum canadense L..*M. alni*
Mesadenia tuberosa (Nutt.) Britton......................................?
Mint ....*E. galeopsidis*
Monarda fistulosa L...?
Morus rubra L...*U. geniculata*
Nasturtium sylvestre, R. Br. See *Roripa sylvestris.*
Oenothera biennis L. See *Onagra biennis.*

Onagra biennis (L.) Scop.......................................*E. polygoni*
Ostrya virginiana (Mill.) Willd.........................*M. alni—Ph. corylea*
Oxalis stricta L...*M. russellii*
Parietaria pennsylvanica Muhl.............................*E. cichoracearum*
Parthenocissus quinquefolia (L.) Planch..........................*U. necator*
Phlox divaricata L...*E. cichoracearum*
Phlox drummondii Hook...*E. cichoracearum*
Phlox procumbens ....*E. cichoracearum*
Phlox sp ....?
Pilea pumila A. Gray. See *Adicea pumila.*
Physostegia virginiana (L.) Beuth..?
Physalis heterophylla Nees...*E. polygoni*
Plantago major L...*E. cichoracearum*
Plantago rugelii Dec...*E. cichoracearum*
Platanus occidentalis L...*M. alni*
Poa pratensis L...*E. graminis*
Polygonum aviculare L..*E. polygoni*
Polygonum erectum L...*E. polygoni*
Polygonum ramosissimum Michx.......................................*E. polygoni*
Populus deltoides Marsh...*U. salicis*
Populus grandidentata Michx..*U. salicis*
Populus monilifera Ait. See *P. deltoides.*
Populus tremuloides Michx..*U. salicis*
Potentilla monspeliensis L...?
Potentilla norvegica L. See *P. monspeliensis.*
Poterium canadense A. Gray. See *Sanguisorba canadensis.*
Prunella vulgaris L....................................*S. humuli fulginea*
Prunus americana Marsh..*Po. oxycanthae*
Prunus avium L...*Po. oxycanthae*
Prunus besseyi Baily..*Po. oxycanthae*
Prunus cerasus L...*Po. oxycanthae*
Prunus pumila L..*Po. oxycanthae*
Prunus sp ....*Po. oxycanthae*
Pyrus malus L. See *Malus malus.*
Quercus alba L...*M. alni extensa*
Quercus macrocarpa Michx...*M. alni*
Quercus palustris DuRoi...................................*M. alni—Ph. corylea*
Quercus prinoides Willd...*M. alni extensa*
Quercus robur ....*M. alni*
Quercus rubra L...........................*M. alni—M. alni extensa—Ph. corylea*
Quercus velutina Lam..........*M. alni—Ph. corylea—Ph. corylea tomentosa*
Ranunculus abortivus L..*E. polygoni*
Rhus glabra L...*S. humuli*
Ribes cynosbati L..*S. mors-uvae*
Ribes gracile Michx..*S. mors-uvae*
Ribes sp...*S. mors-uvae*
Ribes rotundifolium Michx.?...*S. mors-uvae*
Ribes sp...*S. mors-uvae*
Roripa sylvestris (L.) Bess..?

Rosa arkansana Porter .... *S. humuli*
Rosa blanda Ait? .... *S. pannosa*
Rosa sp .... *S. pannosa*
Rudbeckia hirta L .... *E. cichoracearum*
Rudbeckia laciniata L .... ?
Rudbeckia triloba L .... ?
Salix amygdaloides Anders .... *U. salicis*
Salix discolor Muhl .... *U. salicis*
Salix humilis Marsh .... *U. salicis*
Salix sp .... *U. salicis*
Sambucus canadensis L .... *M. grossulariae*
Sanguisorba canadensis L .... *Po. oxycanthae*
Scutellaria lateriflora L .... *E. galeopsidis*
Scutellaria galericulata .... *E. galeopsidis*
Sisymbrium officinale Scop .... ?
Solanum carolinense L .... ?
Solidago canadensis L .... *E. cichoracearum*
Solidago rigida L .... *E. cichoracearum*
Solidago serotina Ait .... *E. cichoracearum*
Solidago serotina gigantea (Ait.) A. Gray .... *E. cichoracearum*
Solidago ulmifolia .... ?
Sonchus oleraceus L .... *S. humuli fuliginea*
Stachys palustris L .... *E. galeopsidis*
Stachys sp .... *E. galeopsidis*
Symphoricarpos symphoricarpos (L.) MacM .... *M. diffusa*
Symphoricarpos vulgaris Michx. See *S. symphoricarpos.*
Syndesmon thalictroides (L.) Hoffing .... *E. polygoni*
Syringa vulgaris L .... *M. alni*
Taraxacum officinale Weber. See *F. taraxacum.*
Taraxacum taraxacum (L.) Karst .... *S. humuli fulginea*
Taraxacum canadense L .... *E. galeopsidis*
Thalictrum purpurascens L .... *E. polygoni*
Tilia americana L .... *U. clintoni*
Ulmus americana L .... *M. alni—U. macrospora—Ph. corylea*
Ulmus racemosa Thomas .... *U. macrospora—Ph. corylea*
Verbena bracteosa Michx .... *E. cichoracearum*
Verbena hastata L .... *E. cichoracearum*
Verbena stricta Vent .... *E. cichoracearum*
Verbena urticifolia L .... *E. cichoracearum*
Verbesina alternifolia (L.) Britton .... *E. cichoracearum*
Veronica virginica L. See *Leptandra virginica.*
Vernonia fasciculata Michx .... *E. cichoracearum*
Vernonia noveboracensis (L.) Willd .... *E. cichoracearum*
Viburnum lentago L .... *M. alni*
Vicia sp .... *M. alni*
Vitis cordifolia Michx .... *U. necator*
Vitis labrusca L .... *U. necator*
Vitis sp .... *U. necator*
Xanthium canadense Mill .... ?
Xanthoxylum americanum Mill .... Ph. corylea

Index to Species and Varieties of Erysiphaceae.

Recognized species are in italics; synonyms are in Roman.

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EXPLANATION OF PLATES.

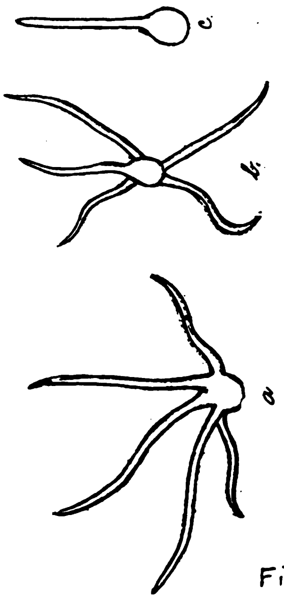

Fig. 1.

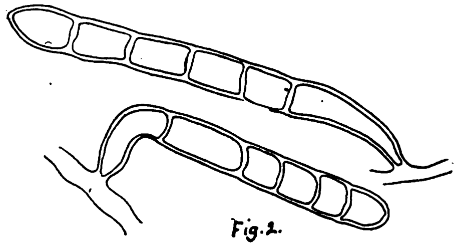

Fig. 2.

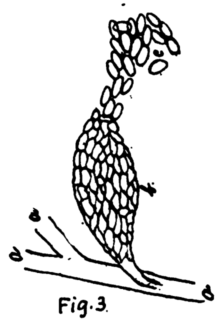

Fig. 3.

PLATE I.

Fig. 1. *Phyllactinia corylea tomentosa.* a and b, two appendages; c, an appendage of the typical *P. corylea* from same leaf as a and b. (Author's illustration.)

Fig. 2. Hyphae and conidia of *Erysiphe cichoracearum,* from leaf of *Hydrophyllum virginicum.* (Drawn by Miss King.)

Fig. 3. A fruit of *Ampelomyces quisqualis.* a. A mycelium of *Erysiphe* with the fruit of *Ampelomyces;* b, arising out of it; c, spores escaping from the ruptured end of fruit. (Author's illustration.)

PLATE II.

(Drawn by Miss King.)

(See page 46.)

Fig. 1. A perithecium of *Uncinula circinata* from a leaf of Acer saccharinum showing very numerous appendages uniformly coiled at apex.

Fig. 2. Perithecia of *Sphaerotheca mors-uvae* from the cultivated gooseberry, showing few or obsolete appendages and the persistent mycelium in which they are immersed.

PLATE III.

(See page 46.)

Showing Variations in *Erysiphe polygoni.* (Drawn by Miss King.)

Fig. 1. From a leaf of *Clematis virginiana,* showing few, but long flexuose appendages.

Fig. 2. From a leaf of *Astragalus carolinianus,* showing more numerous but short *appendages. b.* Tips of appendages.

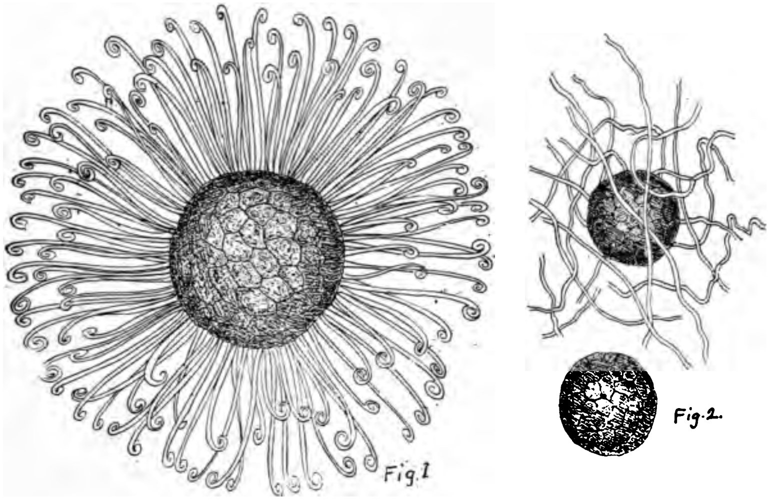

PLATE II.

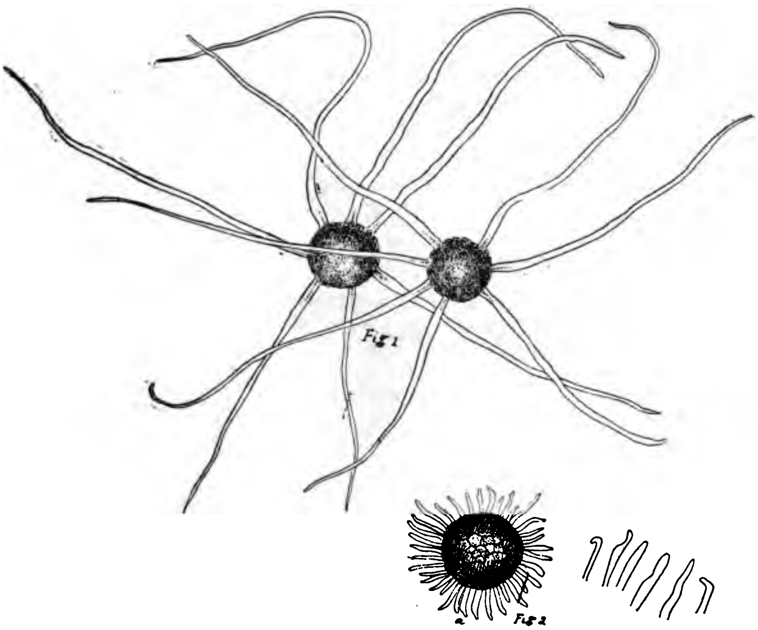

PLATE III.

NOTES ON THE ALGAE OF IOWA.

BY ROBERT EARLE BUCHANAN.

HISTORICAL. The first definite mention of Iowa Algae which has come to our notice is that published by Dr. C. M. Hobby[1] in the Proceedings of the Iowa Academy of Science. His list comprises some twenty-seven genera and seventy-four species and varieties. The list is prefaced as follows: "The species given below were mainly collected in the immediate vicinity of Iowa City. I am greatly indebted to Rev. Francis Wolle, of Bethlehem, Pennsylvania, for assistance in the study and identification of these plants. The classification used is that of Kirchner in "Algen von Schlesien, Breslau, 1878." The list comprises an unusually long list of spirogyras, some eighteen species and one variety.

Two years later, in 1882, J. C. Arthur[2] published his "History of Floyd County" in which he listed a number of species of the algae and the fungi, as well as the higher plants.

In the same year, Prof. C. E. Bessey,[3] then at the Agricultural college, published the following note regarding the abundance and distribution of algae: "The excessively wet autumn in central Iowa caused an unusual growth of the fresh water algae. Every pond and ditch was filled with Spirogyra, Zygnema, Vaucheria, etc., until the first of November. Usually our waters are quite barren of these growths so late in the season, but this season the continued wet weather, instead of the usual drouth, favored their development."

Dr. Bessey[4] in 1884 published a "Preliminary list of Cryptogams of Ames and Vicinity." Under Cyanophyceae eleven determined species are listed, under Palmellaceae 2, Protococcaceae 2, Zoosporae 6, Desmidiaceae 2, Diatomaceae 7 genera, Zygnemaceae 6, Oophytes 7. Total 36 specific determinations.

In 1897 Prof. B. Shimek[5] published a paper entitled "Notes on Aquatic plants from Northern Iowa." There is included in this list a number (eight) of species of algae, two Chaetophoras, four Cladophoras, and one Hydrodictyon.

P. C. Meyers[6] in a paper published in 1899 has given preliminary notes on the distribution of the Diatoms of the state, material having been obtained from a variety of sources.

Pammel and Buchanan published in 1905[9] a short list of algae collected in the northeastern part of Iowa.

Dr. Bruce Fink in 1905[8] published an account of the algae which he has studied in Iowa during a period of years. This is one of the most extended of the lists, twenty-eight species being noted for the first time. Most of the collections described were made in the vicinity of Fayette and of Grinnell.

OBJECT OF STUDY. Iowa is pre-eminently a prairie state, streams and lakes form but a very small proportion of her area. For this reason, perhaps, the algal flora of the state has been neglected, short lists and brief notes only of some of the species have been published at various times. It was deemed of interest, therefore, to undertake a study of the distribution of these forms in the state, as extended as time and facilities would permit. It was considered especially necessary that as extended a list of additions as possible might be made to this flora, as a contribution toward a complete list of these forms to be found within the borders of the state. Class material for demonstration in high school and college is often difficult to procure, hence a study of the habitat of some of the various forms may have a practical significance to many instructors and teachers.

From an economic standpoint, furthermore, some of our species are of importance inasmuch as they are frequently found polluting water supplies, especially those drawn from natural reservoirs. The so-called working of our lakes, and consequent production of foul odors and tastes have at various times caused not a little trouble and some destruction of property.

The study was undertaken at the instigation of Dr. Pammel, and the writer's thanks are due him for his many kindnesses.

The list of algae that is appended here makes no pretence of being at all complete; as a matter of fact, not more than one-quarter of the material collected has been worked over. A little more time would certainly result in the addition of much larger number of species to the flora of the state.

SOURCE OF MATERIAL STUDIED. During the years 1904-5 various collections of algae were made in different parts of the state, aggregating perhaps one hundred fifty. The general localities are as follows: Spirit Lake, East and West Okoboji Lakes, Upper and Lower Gar Lakes, Lake Minnewashta, ponds and marshes in Wright, Story, Polk, Linn, Webster, Hamilton, Humboldt counties, about Cedar Falls in the Cedar and tributaries, at the Ledges near

Boone, Davenport, and contributions have been received from Allamakee and Fayette counties. As before noted only a small part of these collections have as yet been thoroughly worked over, and the remainder awaits our leisure for further study.

Most collections were made in small vials, and preserved in 2% formalin solution. This seems particularly adapted to the preservation of the algae, they remain almost of the normal color and retain their shape well for several years at least.

METHODS OF STUDY. Most of the material studied was mounted in a weak solution of formalin to which had been added a small amount of eosin, the mount then ringed. If the ringing is successful the slides may be preserved for several years at least without change. The eosin is very satisfactory as an aid in the determination of the details of structure.

AUTHORITIES ON IDENTIFICATION. As a guide to the identification of the genera of the forms studied, and to the recognition of the great groups of algae, West's "British Freshwater Algae" has been of the most material assistance. The order in which the various genera are given in the list has been adapted from this work, and the same work has furnished a basis for the majority of the keys that are given therein. The section of Engler and Prantl's Pflanzenfamilien devoted to algae has also been of material assistance in the construction of keys, etc. For description of species in general De Toni's "Sylloge Algarum" has been used, together with Rabenhorst's "Kryptogamen Flora," and Kirchner's "Algen von Schlesien" and more particularly Wolle's "Freshwater Algae of the United States" and "Desmids of the United States" in some groups and genera. The same may be said of "Cooke's British Freshwater Algae." "The Ulothricaceae and Chaetophoraceae of the United States" by Tracy Elliott Hazen was used in part in the determination of the species of these groups. "Protophyta and Phycophyta" of the flora of Nebraska published by the Botanical Seminar of the University and written by DeAlton Saunders has proven of considerable comparative interest also. Bornet and Flahault's "Revision des Nostocacees Heterocystees" was also consulted for determination of species described therein. The lists of the Algae of Minnesota published by Miss Tilden have also been consulted with considerable interest, inasmuch as much of the northern part of the state should have about the same algal flora as a large section of Minnesota.

CLASSIFICATION OF ALGAE. The Classification which has been followed in the main in the arrangement of the various groups of the Algae has been that given by West in his "British Freshwater Algae." He has, however, commenced with the higher or more complex types and proceeds to the simpler and probably the more primitive types. We have altered this order, but otherwise the classification is much as is given.

In the list of Algae keys to different groups have been included and also to the species of each genus of algae as far as they have been found in the state. These keys were prepared for the convenience of the writer in making determinations and are here included because they may prove of assistance to others. In many cases these keys are taken directly from West, in others adapted from West or from Engler and Prantl, and many are original. While considerable care has been used in their preparation, nevertheless, a key is but a clumsy device after all for purposes of identification and these are submitted simply for what they are worth; it is to be understood that no attempt is made to differentiate the species found in the state from other species. Under each species in addition to the name and in a few instances some synonym, there have been given a few notes as to general distribution of the species, its Iowa localities as far as known reported to the writer or others.

Included in some of the keys are genera and groups that have not been recorded for Iowa, but that undoubtedly occur.

CONSIDERATION OF SPECIES OF ALGAE FOUND AND REPORTED.

KEY TO THE CLASSES OF ALGAE.

I. Containing a blue coloring matter known as phycocyanin. The stored product of assimilation probably glycogen for the most part. Mostly fresh water Blue green Algae .... Myxophyceae

II. Containing a brown coloring matter, diatomin (much resembling the phycophaein of the brown algae). Each cell with a siliceous covering. Universal in both fresh and salt water .... Bacillarieae

III. Containing a large proportion of yellow pigment known as xanthophyll. The stored product of assimilation is a fatty substance. Fresh water. Yellow green Algae .... Heterokontae

IV. Containing only the green coloring matter known as chlorophyll. Stored product of assimilation usually starch. Usually fresh water. Green Algae .... Chlorophyceae

V. Containing a brown coloring matter called phycophaein. Mostly marine. Brown Algae .... Phaeophyceae

VI. Containing a reddish coloring matter known as phycoerythrin. Mostly marine .... Rhodophyceae

Of the above classes of Algae the Phaeophyceae and the Rhodophyceae have no recorded representative in our flora and are not included in a discussion of the various classes.

CLASS I.

MYXOPHYCEAE (CYANOPHYCEAE). BLUE GREEN ALGAE.

The members of this class, usually easily distinguished by their characteristic blue green color, are almost ubiquitous in distribution in our flora. Wherever there is moisture, on the trunks of trees, on rocks, on damp soil, either alone or as one of the symbionts of the lichen body, as well as in water both in stagnant and running. Even in the soil they are present, at least in the form of spores or resistant cells of some character.

KEY TO THE SUBCLASSES OF MYXOPHYCEAE.

I. Cells with a low type of chromatophore, often scarcely differentiated and with a primitive type of nucleus........................Archiplastideae

II. Cells with a distinct and highly differentiated type of chromatophore and with true cell nucleus.................................Glaucocystideae

Subclass I.

Archiplastideae.

This subgroup includes all the blue green algae that have been reported from the state.

KEY TO THE ORDERS OF THE ARCHIPLASTIDEAE.

I. Plants unicellular or colonial, commonly imbedded in gelatinous matrix, more rarely free floating..............................Coccogoneae

II. Plants filamentous, filaments simple or branched, generally consisting of one or more rows of cells within a sheath attached to a substratum or free floating ....Hormogoneae

Order I.

Coccogoneae.

KEY TO THE FAMILIES OF COCCOGONEAE.

I. Cells epiphytic, with a distinct base and apex; reproduction by the formation of gonidia only.............................Chamaesiphonaceae

II. Cells or colonies free floating or forming a gelatinous stratum very rarely epiphytic, not differentiated into base and apex, multiplication by simple cell division, very rarely by means of gonidia...........Chroococcaceae

Family I.

Chamaesiphonaceae.

I. Chamaesiphon.

1. *C. incrustans.* Grun. Small round celled epiphyte. Cells 4 u.

This form has been collected but once, then growing on the surface of some alga, probably an Oedogonium.

Eagle Grove. Hewitt's Pond. 1904. R. E. Buchanan.

Family II.

Chroococcaceae.

KEY TO THE SUBFAMILIES OF CHROOCOCCACEAE.

I. Ephiphytes, with well defined dorsiventrality..............Chroocysteae
II. Free floating or in a gelatinous stratum, no dorsiventrality..Chroococceae

SUBFAMILY I.

CHROOCYSTEAE.

None of the species belonging to this subfamily have been reported from Iowa, but it is probable that some of them, particularly the Gloeochaete, may be found attached to submerged mosses or algae.

SUBFAMILY II.

CHROOCOCCEAE.

This group includes many of the very lowest forms of the algae, some of them bearing evidence of their relationship to the bacteria. There is a considerable number of genera that are native to the state.

KEY TO THE GENERA OF THE CHROOCOCCEAE.

A. Cell division in two directions only, forming plane........*1. Merismopedia*
B. Cell division in all directions of space, cells enveloped in mucus.
 *Cells forming large colonies.
  +Cells arranged at or toward the periphery of large colonies. Spherical.
   =Cells closely and regularly arranged...............2. *Coelosphaerium*
   ==Cells geminate and sparsely scattered, markedly pyriform in shape ....3. *Gomphosphaeria*
  ++Cells densely aggregated in globose, elongated, or clathrate colonies ....4. *Microcystis*
  +++Cells aggregated to form irregular gelatinous colonies.
   =Individual mucous coats clearly evident around each cell..5. *Gloeocapsa*
   ==Cells involved in a common mucous covering.......(6. *Aphanocapsa*)
   ===Cells arranged in a compact gelatinous stratum...7. *Porphyridium*
 **Cells more or less solitary, or forming very small colonies..8. *Chroococcus*

1. *Merismopedia.*

KEY TO THE SPECIES.

Diameter of cells 3.3u-3.8u................................*M. glauca*
Diameter of cells 6.5-9.5u................................*M. elegans*

2. M. glauca. (Ehrenb.) Naeg.

This alga is common floating in the quiet waters of ponds.

Ames, 1884? C. E. Bessey. (As *M. nova*).
Grinnell and Fayette. Bruce Fink.
Eagle Grove, Hewitt's Pond. '04. R. E. Buchanan.

3. M. elegans A. Br.

A form agreeing with this species in all essential characteristics has been once collected. Cells 7u in diameter.

Eagle Grove. Slough bottom. 1904. R. E. Buchanan.

2. *Coelosphaerium.*

4. C. kuetzingianum Naeg.

A frequent alga in many permanent ponds, often floating in considerable quantities in the lakes.

South Gar Lake. Dickinson Co. 1904. R. E. Buchanan.
Eagle Grove. Hewitt's Pond. 1904. R. E. Buchanan.
Eagle Grove. Margin of Slough. 1904. R. E. Buchanan.
Collections have been made several times since in similar localities around Eagle Grove.

3. *Gomphosphaeria.*

5. G. aponina Kutz.

Found once only. Should be common in stagnant water.

Eagle Grove. Stagnant Pool. 1904. R. E. Buchanan.

4. *Microcystis.*

6. M. aeruginosa.

Very abundant in the first locality.

East Okoboji Lake. Oct. 1904. R. E. Buchanan.
Ames. 1884. C. E. Bessey.

5. *Gloeocapsa.*

KEY TO THE SPECIES.

Integuments colorless. Cells 2-4u in diameter..............*G. arenaria*
Integuments yellow to brown..............................*G. magma*

7. G. arenaria.

Forms thin aeruginous coating on damp stone, etc.

Grinnell. 1905. Dr. Bruce Fink.
Ames. Abundant on flower pots in greenhouse. 1904. R. E. Buchanan.

8. G. magma.

Fayette. On granitic boulders. Bruce Fink.

6. *Aphanocapsa.*

9. Grevillei? (Hass.) Rabenh.

A form referred to this species has been found once in stagnant water.

Ames. Pond, near R. R. 1905. R. E. Buchanan.

7. *Porphyridium.*

10. P. cruentum. (Ag.) Naeg.

This alga has been collected several times on the lower part of the stone wall on the arch in the college park.

Ames. On stone wall. 1904. R. E. Buchanan.

8. *Chroococcus.*

11. *C. refractus.*

Ames. 1884. C. E. Bessey.

Order II.

Hormogoneae.

KEY TO THE SUBORDERS OF THE HORMOGONEAE.

I. Trichomes cylindrical, sometimes narrowed at the extremities.......... .... Psilonemateae

II. Trichomes conspicuously attenuated toward one or both extremeties, which are generally piliferous................................Trichophoreae

Suborder I.

Psilonemateae.

KEY TO THE FAMILIES OF THE PSILONEMATEAE.

I. Filaments with a false branch system; sheaths firm and tubular of more or less equal thickness; trichomes consisting of a single row of cells, with heterocysts, but not of uniform thickness..........Scytonemaceae

II. Trichomes commonly tortuous and intricate, enveloped within a large gelatinous mass, consisting of a single row of uniform cells, generally torulose, with heterocysts; sheaths very delicate, mostly confluent...... .... Nostocaceae

III. Trichomes consisting of a simple row of cells, uniform along their entire length except for the apical cells, which are sometime attenuated; heterocysts absent; sheaths variable, more or less gelatinous, and sometimes enclosing more than one trichome................Oscillatoriaceae

Family I.

Scytonemaceae.

1. *Scytonema.*

KEY TO THE SPECIES.

Superficially corrugated or hirsute, as if erose..........*S. tomentosum*

Superficially smooth, sometimes the external layers dissolved into hairs ....*S. myochrous*

12. *S. tomentosum.*

Iowa City. 1880. Hobby.
1905 Fink.

13. *S. myochrous.*

Fayette. 1905. Fink.

Family II.

Nostocaceae.

KEY TO THE GENERA OF NOSTOCACEAE.

A. Trichomes flexuose and contorted within a definite gelatinous investment ....1. Nostoc

B. Trichomes more or less straight, free or forming a thin mucus stratum

a. Heterocysts and spores intercalary..................2. Anabaena

b. Heterocysts terminal and spores always contiguous to them........ ....3. Cylindrospermum

1. *Nostoc.*

KEY TO THE SPECIES.

Thalli confluent, on soil or more frequently mosses........*N. muscorum*

Thalli discrete, periderm firm.

Terrestrial.

Thallus becoming irregular, tongue-shaped, etc........*N. commune*

Thallus remaining usually spherical or subglobose...*N. sphaericum*

Aquatic.

Trichomes densely intricate........................*N. coeruleum*

Trichomes loosely implicate, radiating from the center.*N. pruniform*

14. N. muscorum. Agardh.

On the stem of mosses.

Fayette. 1905. Fink.

15. N. commune. Vaucher.

A very common alga in the damp margins of marshy places, etc.

Iowa City. 1880. Hobby.
Ames. 1884. Bessey.
Grinnell. Fink.
Ames. 1904. Buchanan.
Eagle Grove. 1904. Buchanan.

16. N. sphaericum Vaucher.

Iowa City. Hobby.
Ames. Bessey.

17. N. coeruleum Lyngbye.

Ames. 1884. Bessey.

18. N. pruniforme. Agardh.

Fayette. Fink. Nodules often reaching the size of plum.
Ames. Buchanan. In pool near Ontario. Very small.

2. *Anabaena.*

KEY TO THE SPECIES.

Growing in roots of the Cycas........................*A. cycadacearum*

Not in roots.

Filaments straight, at least not spiral. Spores 7-13u broad........... ....*A. flos-aquae*

19. A. cycadacearum. Reinke.

Filaments curved, spores 16-18u........................*A. circinalis*

Occurring as the cause of the nodular thickenings on the roots of the Cycas revoluta wherever grown.

Ames. Greenhouse. Buchanan.

20. A. flos-aquae. Breb.

One of the most common (together with the next) of the constitutents of the plankton of many of our lakes at some seasons of the year. Occurs frequently in the sloughs in the northern part of the state also.

Eagle Grove, Jenning's Pond. 1904. Buchanan.

Eagle Grove, Pond near Boone River. Buchanan.

Eagle Grove, Slough. 1904. Buchanan.

Collected some eight or ten times under similar conditions to the above.

21. A. circinalis. Rabenh.

Very common in the lakes.

East Okoboji Lake. October. 1904. Buchanan.

Upper Gar Lake. October. 1904. Buchanan.

3. *Cylindrospermum.*

KEY TO THE SPECIES.

(It is impossible to give a key to the species that occur in Iowa, inasmuch as only one has come to the notice of the writer, and the names that have been used by other writers may mean any one of several species, at least as recognized by Bornet and Flahault).

22. C. limnicola Kg.

Iowa City. Hobby.

Ames. Soil on pots in greenhouse. Buchanan.

23. C. comatum Wood.

Grinnell. Frequent on wet soil along brooks. Fink.

24. C. macrospermum Kg.

Iowa City. Hobby.

Family III.

Oscillatoriaceae.

KEY TO THE SUBFAMILIES.

I. Several trichomes included in a single sheath..............Vaginarieae

II. Single trichome in a sheath.................................Lyngbyeae

Subfamily I.

Vaginarieae.

1. *Microcoleus.*

25. M. vaginatus (Vauch) Comont. (*M. terrestris* Kg.)

Grinnell. Damp Ground. Fink.

Ames. On flower pots in greenhouse. Buchanan.

Subfamily II.

Lyngbyeae.

KEY TO THE GENERA.

Trichomes consisting of many cells.

Filaments simple; sheaths firm, apices of trichomes straight..1. Lyngbya

Filaments simple; sheaths thin, always hyaline, mucous and more or less diffluent, in some species absent, apices of the trichomes commonly curved.

Trichomes more or less agglutinated by their mucous sheaths; cells of the trichome often separated by a thin mucous layer....2. Phormidium

Trichomes destitute of sheaths, free, straight or with curved extremities ....3. Oscillatoria

Trichomes consisting of one cell, twisted into a regular spiral...4. Spirulina

1. *Lyngbya.*

26. *L. vulgaris* (Kuetz) Kirch.

Iowa City. Hobby.

Grinnell. Damp Soil. Fink.

27. *L. ochracea* (Kuetz) Thur.

Iowa City. Hobby.

Eagle Grove. In the trough of a flowing well. It is found very commonly in the waters in this locality that are laden with iron, the sheath becoming impregnated with this substance. Buchanan.

28. *L. obscyra.* Kuetz.

Eagle Grove. A pond amid bladderwort. Buchanan.

29. *L. subtorulosa* (Breb.) Wolle. (*Phormidium lacustre* Naeg.)

Iowa City. Hobby.

30. *L. cataracta* (Rabenh.) Wolle. (*Phormidium cataractum* Rab.)

Iowa City. Hobby.

31. *L. glutinosa* Ag. (*Phormidium glutinosum* A Br.)

2. *Phormidium.*

32. *P. tenue* (Menegh) Gomont.

Fayette. Frequent. Fink.

Ames. On pots in greenhouse. Buchanan.

Ames. Pond. Buchanan.

Eagle Grove. In pond among decaying rushes. Buchanan.

Eagle Grove. Bottom of the margin of the slough. Buchanan.

3. *Oscillatoria.*

KEY TO THE SPECIES.

Filaments very narrow, divisions often not evident.

Filaments .6 u in diameter..............................*O. angustissima*

Filaments 1.8-2.5 u in diameter..............................*O. tenerrima*

Filaments broader, articulations usually distinct.

Articulations about half as long as wide.

Filaments 5.5-6.5 u in diameter................................*O. tenuis*
Filaments 6.5-8.5 u in diameter................................*O. limosa*
Filaments 9-10 u in diameter...................................*O. nigra*
Articulations less than half as long as broad.
Filaments 12-18 u in diameter.
Forming greenish stratum..............................*O. froelichii*
Forming dark olive brown stratum..................*O. froelichii fusca*
Filaments broader than 18 u.
Filaments 30-45 u in diameter, 4-5 articulations to the width..........
....*O. princeps*
Filaments 38-56 u in diameter, 9 articulations to a diameter..........
....*O. imperator*

33. *O. angustissima* W&G. S. West.

Ontario, Ia. In pond with other algae. Buchanan.

34. *O. tenerrima* Kuetz.

A common species in stagnant water, and on soil.

Fayette. Fink.

Ames. Effluent of the filter beds of the College Sewage disposal plant. Buchanan.

Ames. On the soil in greenhouse. Buchanan.

Eagle Grove. Pond. Buchanan.

35. *O. tenuis.* Ag.

This is the most common of the Oscillarias, being almost universally present in stagnant water, and in slow running streams, where water drops upon the soil, on boards, etc.

Iowa City. Hobby.

Grinnell. Fink.

Allamakee Co. Spring. Pammel.

Eagle Grove. Hewitt's Pond. Amid Utricularia. Buchanan.

Eagle Grove. From a watering trough. Buchanan.

Eagle Grove. Stone under a water drop, very dense mat. Buchanan.

Ames. Board from a spring. Buchanan.

Ames. Effluent of the filter beds. Buchanan.

And many similar localities.

36. *O. limosa.* Vauch.

Next to the tenuis this is probably the commonest species in the state.

Iowa City. Hobby.

Ames. Bessey.

Fayette. Fink.

Ames. On damp earth, forming a thin coating. Buchanan.

Eagle Grove. Moist earth. Buchanan.

37. *O. nigra* Vauch.

Usually floating free in stagnant water.

Iowa City. Hobby.

Ames. Bessey.

Ames, stagnant ditch. Buchanan.

38. *O. froelichii* Kuetz.

Floating among other algae in ponds.

Iowa City. Hobby.

Eagle Grove. Floating in Hewitt's Pond. Buchanan.

39. O. *froelichii* var. *fusca* Kirch.

Ames, Ia. On moist soil in the greenhouse. Buchanan.

40. O. *princeps* Vauch.

Fayette. Fink.

Eagle Grove. Pond, amid dense growth of Lemna. Buchanan.

41. O. *imperator* Wood.

The largest species of oscillaria that is to be found in the state.

Ames. Bessey.

4. *Spirulina.*

42. S. *major* Kutz.

Ontario. Slough, amid Lemna trisulca. Buchanan.

Suborder II.

Trichophoreae.

KEY TO FAMILIES.

I. Trichomes attenuated from the base to the apex, which is piliferous; heterocysts basal, rarely absent........................Rivulariaceae

II. Trichomes attenuated from the middle toward each extremity. Heterocysts absent ....Camptotrichaceae

Family I.

Rivulariaceae.

KEY TO THE GENERA.

Filaments free, simple or falsely branched, branches distinct and free........ ....1. Calothrix

Filaments forming a hemispherical or globular thallus, closely united by mucus.

Filaments radiately disposed in a tough globose or hemispherical attached thallus. Spores unknown............................2. Rivularia

Filaments radiately disposed in a soft globose free floating thallus. Spores regularly produced................................3. Gloeotrichia

1. *Calothrix* (Mastigonema).

43. C. *elongatum* (Wood).

Ames. Bessey.

44. C. *parietina* (Naeg.) Thur.

Ontario. On stem of Phragmites. Buchanan.

2. *Rivularia.*

No species of Rivularia as at present recognized has been found in the state, the species reported by Bessey as *R. cartilaginea* is probably *Gloeotricha pisum.*

3. *Gloeotricha.*

45. G. *Pisum* Thur.

One of the most abundant of the algae in some of the lakes at certain seasons of the year.

Iowa City. 1880. Hobby.

Ames. 1884. Bessey.

South Gar Lake. 1904. Buchanan.
North Gar Lake, on weeds in shallow water, 1904. Buchanan.
Allamakee County. 1905. L. H. Pammel.

Family II.

Camptotrichaceae.

No species or genera belonging to this family have as yet been described from the state.

Subclass.

Glaucocystideae.

None of the representatives of this more highly differentiated group of the Myxophyceae have been reported from Iowa. Perhaps Glaucocystis may be found in the northern part of the state.

CLASS II.

BACILLARIEAE (DIATOMS).

Although a large number of Diatoms have been collected when collecting other forms of algae, no attempt has been made to classify them with the exception of one or two cases. The diatoms have an almost universal distribution over the state. Some work on their distribution in this state has been done by other authors, but a most interesting field is here for anyone who has the time and ability to take it up. Species belonging to the following genera have been noted, with only occasional specific identification:

Centricae.
  Discoideae.
    Melosiraceae.
46. *Melosira.* *M. granulata.* Lake Okoboji and Gar Lake.
    Coscinodiscaceae.
47. *Stephanodiscus.* *S. niagarae* Ehr. Gar Lake, surface.
Pennatae.
  Fragilarioideae.
    Tabellariaceae.
48. *Tabellaria.* *T. fenestrata.* (Lyngb) Kutz. Gar Lake.
    Meridionaceae.
      Meridion.
    Diatomaceae.
49. *Diatoma.* *D. vulgare* Bory. Pond, Eagle Grove Buchanan.
    Fragilariaceae.
      Fragilaria.
      Synedra.
    Eunotiaceae.
      Eunotia.

Achnanthoideae.
Cocconeidaceae.
Cocconeis. C. placentula Ehrenb. Abundant on old bladderwort in pond, Ontario. Buchanan.

50. Naviculoideae.
Naviculaceae.
Navicula. Numerous species.
Stauroneis.
Amphipleura.
Gyrosigma (Pleurosigma)
Gonphonemaceae
Gonphonema
Cocconemaceae
Cocconema.
Amphora. A. ovalis. Kutz. Pond, Eagle Grove. Buchanan.
Epithemia.

Nitzschioideae.
Nitzschiaceae.
Nitzschia. Very common.

Surirelloideae.
Surirellaceae.
Surirella.

Class III.

HETEROKONTAE.

This class is one that has been segregated from the Chlorophyceae to receive certain anomalous forms that seemed to have uncertain affinities. Of the three families created, two are found in the state.

Order I.

Confervales.

KEY TO THE FAMILIES.

Unicellular or filamentous; cells often elongate, uninucleate or subcoenocytic, with several or many chromatophores; cell walls firm and thick ....Tribonemaceae
Plant body large and coenocytic, fixed, with well developed organs of attachment; chromatophores numerous..................Botrydiaceae

Family I.

Tribonemaceae.

This family as far as known is represented in this state by one genus only, Tribonema.

1. *Tribonema.*

KEY TO THE SPECIES.

Chromatophores usually numerous, cell wall thin.
  Diameter of filaments 6-11 u..........................*T. bombycinum*
  Diameter of filaments 3-6 u........................*T. bombycinum tenue*
Chromatophores numerous, large, cell wall thicker, diameter of cell 11-16.5 u ....*T. utriculosum*

51. T. bombycinum (Agardh) Derb. & Sol.

Very common in stagnant water, and even slow flowing water and springs.

Eagle Grove. Slough, margin of. Buchanan.
Ames. Floating in spring. Buchanan.

52. T. bombycinum tenue Hazen.

Eagle Grove. Slough. Buchanan.
Eagle Grove. In pond amid Lemna. Buchanan.

53. T. utriculosum (Kutz) Hazen.

Eagle Grove. In rain barrel by the side of railroad.
Eagle Grove. Pond by the side of the railroad.
Ames. In pond near Ontario. Buchanan.

Family II.

Botrydiaceae.

1. *Botrydium.*

54. B. granulatum (L.) Crev.

Occurs abundantly on mud just drying up, such as that found on the banks of a stream that has overflowed.

Ames. 1884. On damp earth in autumn, forming a green coating. Bessey.
Universally distributed in the state. Fink.
Ames. Common in muddy places. Buchanan.

Class IV.

CHLOROPHYCEAE.

This is the group to which by far the larger part of the algae found in the state belong. It has normally no other color than the chlorophyll pigment, and may generally on that account be easily recognized.

KEY TO THE ORDERS OF THE CHLOROPHYCEAE.

1. Thallus filamentous or unicellular.
   - A. Thallus coenocytic, unseptate. Chloroplasts numerous, without pyrenoids. Sexual reproduction heterogamous............VII. Siphoneae
   - B. Thallus not coenocytic.
     - a. Small unicellular, multicellular or colonial algae. Cells uninucleate or coenocytic. Chloroplasts very variable in form, size and disposition, with or without pyrenoids. Sexual reproduction isogamous or heterogamous. Mostly fresh water.........IX. Protococcales
     - b. Not characterized as a.

1. Sexual reproduction by isogamous aplanogametes. Thallus unicellular or filamentous. Cells uninucleate chloroplasts single or several, usually large and of some definite shape, with pyrenoids ....VIII. Conjugatae
2. Sexual reproduction not by isogamous aplanogametes.
   *Chloroplast single.
   +Without pyrenoids. Cells uninucleate, with a large parietal, reticulated or band like chloroplast. Thallus filamentous unbranched....................................V. Microsporales
   ++With one pyrenoid. Chloroplast single, central and substellate. Mostly subaerial. Thallus filamentous, sometimes parenchymatous or expanded by the fusion of the filaments in one plane.... ....IV. Schizogoniales
   +++Pyrenoid one or more. Cells uninucleate, with a large parietal anastomosing chloroplast containing one or several pyrenoids. Thallus filamentous, simple or branched. Cell division characterized by the intercalation of a new piece of cell wall between the mother cell and the distal end of the daughter cell. Sexual reproduction by means of heterogamous gametes. Zoogonidia with an anterior circle of cilia. Exclusively fresh water forms...... ....I. Oedogoniales
   **Chloroplasts generally one or more, parietal, with pyrenoids. Cells uninucleate. Sexual reproduction either isogamous or heterogamous, sometimes simple, but more often branched..II. Chaetophorales
   ***Chloroplasts numerous, parietal, each with a pyrenoid. Thallus filamentous, simple or branched, incompletely septate. Sexual reproduction isogamous or heterogamous. Marine or fresh water.... ....IV. Cladophorales

II. Thallus expanded, membranous, parenchymatous, attached at least when young. Cells uni-nucleate; chloroplasts single, parietal and with one pyrenoid. Sexual reproduction isogamous. Mostly marine forms...... ....III. Ulvales

Order I.

Oedogoniales.

Only one family.

Family I.

Oedogoniaceae.

One genus only has been reported from the state................*Oedogonium*

.. *Oedogonium.*

KEY TO THE SPECIES OF OEDOGONIUM.

A. Monoecious species. (Oogonia and antheridia born in same filament).
  1. Oogonia always destitute of median processes.
    a. Diameter vegetative cells 7-9 u......................*O. cryptoporum*
    b. Diameter vegetative cells 12-19 u.
      *Terminal cell of filament with an apical bristle, short....*O. autumnale*
      **Terminal cell without apical bristle.......................*O. fragile*

B. Dioecious species.
 1. Nannandrous (with dwarf males).
  a. Dwarf males unicellular............................*O. cataractum*
 2. Macrandrous.
  a. Oogonia little or not at all swollen......................*O. capillare*
  b. Oogonia manifestly swollen.
   *Diameter female cells 9-12 u.....................*O. franklinianum*
   **Diameter female vegetative cell 12-30 u.
    +Diameter oospore 28-35 u.........................*O. pringsheimii*
    ++Diameter oospore greater.
     =Diameter male vegetative cells 15-25 u............*O. cardiacum*
     ==Diameter male vegetative filaments 14-16 u......*O. carbonicum*

C. Organs of fructification imperfectly known.
 1. Oospores globose or sub-globose.........................*O. fonticolum*
 2. Oospores ellipsoid or oval.
  a. Diameter vegetative cells 30-42 u...................*O. giganteum*
  b. Diameter vegetative cells 5-6 u..........................*O. longatum*

55. *O. cryptoporum* Wittr.

Iowa City. Hobby.

56. *O. autumnale* Wittr.

Iowa City. Hobby.

57. *O. fragile* Wittr.

Iowa City. Hobby.

58. *O. cataractum* Wolle.

A species that has been referred to this species provisionally has been found several times in stagnant water. Answers description very well, but for the habitat, which Wolle gives as rapids.

Ames. 1905. Buchanan.

59. *O. capillare* (L.) Kuetz.

One of the commoner forms. Specimens were often found which were referred here, but were not fruiting.

Iowa City. Hobby.

Ames. Pond. 1905. Buchanan.

60. *O. franklinianum* Wittr.

Gar Lake, attached to weeds, very abundant. Buchanan.

61. *O. pringsheimii* Gram.

Iowa City. Hobby.

62. *O. cardiacum* (Hass.) Kuetz. (*O. inequale*).

Ames. Bessey.

63. *O. carbonicum* Wittr.

Wolle in Fresh Water Algae says: "The only specimens of this species identified were from Iowa."

Iowa City. Hobby.

64. *O. fonticolum* A. Br.

Iowa City. Hobby.

65. *O. giganteum* Kuetz.

Iowa City. Hobby.

66. *O. longatum* Kuetz.

Ames. Bessey.

Order II.

Chaetophorales.

KEY TO THE FAMILIES.

. Filaments simple.
1. Chloroplast single, parietal with one or more pyrenoids. Sexual reproduction isogamous ....III. Ulotrichaceae
2. Cells with thick lamellose coats, usually arranged in a single series within a lamellose gelatinous sheath. Sexual reproduction heterogamous; plants monoecious; oogonia with one non-motile oosphere; fertilization within the oogonium...........................IV. Cylindrocapsaceae

B. Filaments branched.
1. With trichomes, or hairs on some part.
   a. Trichomes not terminal.
      *Filaments creeping, trichomes on most of the cells, often swollen at the base, epiphytic on submerged plants. Sexual reproduction heterogamous, plants monoecious, oospheres motile, fertilization taking place outside the oogonium..........................II. Herposteiraceae
      **Filaments forming flat expansions or pulvinate branched masses, epiphytic on the stems and leaves of submerged plants. Sexual reproduction heterogamous; plants monoecious or dioecious; oogonia with a trichogyne and one non-motile oosphere; fertilization within the oogonium and resulting in the formations of a cortical layer on the outer surface of the oogonium. Some of the cells of the thallus are furnished with fine bristles with basal sheaths. I. Coleochaetaceae
   b. Trichomes terminal, branches attenuated into multicellular hair-like prolongations. Chloroplast single, parietal, with one or many pyrenoids. All the cells except those of the rhizoids and hairs are capable of producing zoogonidia or gametes. Sexual reproduction isogamous........ ....V. Chaetophoraceae
2. Without trichomes.
   a. Chloroplast single, parietal, with or without a single pyrenoid. Branches scarcely attenuated. Zoogonidia and gametes produced in special cells. Sexual reproduction isogamous.......VI. Microthamniaceae
   b. Chloroplasts several, parietal, without pyrenoids. Zoogonidia and gametes produced in special gonidangia. Sexual reproduction isogamous. Thallus branched, terrestrial or arboreal........VII. Trentepholiaceae

Family I.

Coleochaetaceae.

Coleochaete.

KEY TO THE SPECIES.

Filaments not closely united into a membrane................*C. soluta*
Filaments closely united into a membrane.
   Thallus not circular...................................*C. scutata*
   Thallus circular ....*C. orbicularis*

67. C. soluta. Pringsh.

Fayette. Fink.

68. C. scutata Breb.

Fayette. Fink.

69. C. orbicularis. Pringsh.

Ames. In aquarium. Buchanan.

Family II.

Herposteiraceae.

No species of this family have been reported from the state, althoug Herposteiron will probably be found.

Family III.

Ulotrichaceae.

KEY TO THE GENERA.

Filaments threadlike, cells cylindrical with truncate apices.
Component cells longer than broad.........................I. Uloth
Component cells in part broader than long..............2. Schizom
Filaments fragile, cells with rounded apices, cells cylindric, resembling a fr mented Ulothrix ....3. Stichococ

1. *Ulothrix.*

70. U. tenerrima Kutz.

Abundant in many places, slow running water or stagnant pools.
Iowa City. Hobby.
Ames. Buchanan.
Eagle Grove. Buchanan.

2. *Schizomeris.*

71. S. leillinii Kutz.

Iowa City. Hobby.

3. *Stichococcus.*

72. S. bacillaris Nag.

Ames, Iowa. Spring on College farm. Buchanan.

Family IV.

Cylindrocapsaceae.

1. *Cylindrocapsa.*

73. C. conferta West.

A species has been found at Ames which agrees exactly with West's figure
Ames. Pond, amid Gloeotricha. Buchanan.

Family V.

Chaetophoraceae.

KEY TO THE GENERA.

Filaments fine, showing little difference in character of the stem branches ....1. Myxo

Filamentsfine, involved in tufts in dense gelatinous substance..........
....2. Chaetophora
Filaments and main branches larger, bearing dense fascicles of small branchlets ....3. Draparnaldia

1. *Myxonema (Stigeoclonium)*

KEY TO THE SPECIES.

Opposite branching predominating.
Filaments 11-30 u in diameter.........................*M. flagelliferum*
Filaments 7-10 u in diameter...............................*M. tenue*
Alternate branching predominating, diameter 6-8 u..............*M. nanum*

74. *M. flagelligerum* (Kutz) Rabenh.
Iowa City. Hobby.

75. *M. tenue* (Ag.) Rabenh.
Iowa City. Hobby.
Ames. Main effluent filter beds. Buchanan.

76. *M. nanum* (Dillw.) Hazen.
Fayette. Fink.
Grinnell. Fink.
Ames. College Spring. Buchanan.

2. *Chaetophora.*

KEY TO THE SPECIES.

Colonies of filaments subglobose or tuberculose. Branching erect, fasciculate at the summit.................................*C. pisiformis*
Colonies of filaments extended, irregularly lobed or laciniate............
....*C. incrassata*

77. *C. pisiformis* (Roth) Agardh.
Iowa City. Hobby.
West Okoboji. Common. Shimek.
Fayette. Fink.
Eagle Grove, Jenning's Pond. Buchanan.
Ontario Pond. Buchanan.
Ames. Pond near R. R. Buchanan.

78. *C. incrassata* (Hudson) Hazen. (*cornu-damae*).
Fayette. Fink.
Allamakee Co. Pammel.

79. *C. monilifera* Kutz.
Clear Lake. On Cladophora. Shimek.

3. *Draparnaldia.*

KEY TO THE SPECIES.

Rachis clearly traceable to or beyond the summits of the fascicles of branches ....*D. plumosa*
Rachis soon lost in the ramifications of the orbicular spreading fascicles
....*D. glomerata*

80. *D. plumosa* (Vauch.) Agardh.
Ames. Bessey.
Fayette. Fink.

81. *D. glomerata* (Vauch.) Agardh.
Iowa City. Hobby.

Family VI.

Microthamniaceae.

No species of this family have as yet been reported from the state, though some probably occur.

Family VII.

Trentepohliaceae.

1. *Trentepohlia (Chroolepus)*

82. T. odorata Wittr. *(umbrina).*

Fayette. Fink.
Grinnell. Fink.

Order III.

Ulvales.

No species of this order have been reported from the state.

Order IV.

Schizogoniales.

No species of this order have as yet been reported from the state.

Order V.

Microsporales.

Family I.

Microsporaceae.

1. *Microspora.*

KEY TO THE SPECIES.

Filaments large, cell wall 1.5-3 u thick.........................*M. amoena*
Filaments smaller, cell walls thin.
  Cell diameter 14-17 u..................................*M. floccosa*
  Cell diameter 7.5-9.5 u..................................*M. stagnorum*

83. M. amoena Rabenh.

Fayette. Fink.
Grinnell. Fink.

84. M. floccosa Thur.

Ames. College Spring. Floating. Buchanan and Holden.

85. M. stagnorum Lagerh.

Eagle Grove. Slough, amid bladderwort. Buchanan.

Order VI.

Cladophorales.

KEY TO THE FAMILIES.

Thallus branched.
Without large barrel shaped resting spores..........I. Cladophoraceae
With large barrel shaped asexual spores............II. Pithophoraceae
Thallus unbranched ....III. Sphaeropleaceae

Family I.

Cladophoraceae.

1. *Cladophora.*

KEY TO THE SPECIES.

At first attached as tufts, afterwards floating as mats.
Cell membrane smooth, articulations more or less swollen........*C. fracta*
Filaments thin, long, sparingly branched, green.....*C. fracta gossypina*
Filaments shorter, much branched, in brownish or nearly black masses ....*C. fracta rigidua*
Cell membrane delicately plicate striate....................*C. crispata*
Tufts permanently attached, branches not connate at the base..*C. glomerata*
2-4 inches long, branches somewhat scattered, ultimate cells penicillate fascicles....................................*C. glomerata rivularis*
Barely one inch long, corymbosely fasciculate, erect..*C. glomerata pumila*

86. *C. fracta* Kuetz.
Iowa City. Hobby.
Ames. Bessey.
West Okoboji. Common. Shimek.
Arbor Lake. Grinnell. Fink.
Eagle Grove. Jenning's Pond. Buchanan.
Eagle Grove. Railroad Pond. Buchanan.
Ames, near Ontario. Buchanan.

87. *C. fracta* var. *gossypina* Rabenh.
West Okoboji. Shimek.

88. *C. fracta* var. *rigidula* Rabenh.
Grinnell. Arbor Lake. Fink.

89. *C. crispata* Kuetz.
Iowa City. Hobby.
Fayette. Quiet water of Volga. Fink.
Grinnell. Fink.

90. *C. glomerata* Kuetz.
Iowa City. Hobby.
Ames. Common in streams. Bessey.
West Okoboji. Common. Shimek.
North Gar Lake. On weeds. Buchanan.
Fayette. Common in Volga. Fink.

91. *C. glomerata* var. *rivularis* Rabenh.
Fayette. Volga, quiet waters. Fink.

92. *C. glomerata* var. *pumila* Bail.
Fayette. Volga, quiet waters. Fink.

Family II.

Pithophoraceae.

No species of this family have been reported from the state.

Family III.

No species of this family have been reported as yet.

Order VII.

Siphoneae.

Family I.

Vaucheriaceae.

KEY TO THE SPECIES.

1. Vaucheria.
  Antheridia little or not at all bent, oblong cylindric or lanceolate.
    Filaments thick +100 u., oogonia erect.........................*V. aversa*
    Filaments thinner, 50-75 u. oogonia lateral....................*V. sericea*
  Antheridia bent in the form of a horn or hook.
    Oogonia sesile or nearly so, beside the antheridia on the thallus.
      Oogonia usually single, sometimes two together, globose or ellipsoid.. ....*V. Dillwynii*
      Oogonia usually in clusters of two or more, ovate or oblong oval....... ....*V. sessilis*
    Oogonia on a fruit branch with the antheridia above.
      Antheridia and oogonia bending in opposite planes, forming an angle with each other, usually two oogonia....................*V. geminata*
        Oogonia 3-10..............................*V. geminata racemosa*
      Antheridia and oogonia bending in parallel planes........*V. terrestris*

93. *V. aversa* Hass.
Fayette. Fink.

94. *V. sericea* Lyngb.
Iowa City. Hobby.

95. *V. dillwynii* Ag.
Iowa City. Hobby.

96. *V. sessilis* DC.
Iowa City. Hobby.
Ames. Bessey.
Fayette. Fink.
Grinnell. Fink.
Ames. Pots in Greenhouse. Buchanan.
Eagle Grove. Hewett's Pond. Buchanan.
Fayette Co. Pammel.

97. *V. geminata* DC.
Iowa City. Hobby.
Ames. Bessey.
Fayette. Fink.
Grinnell. Fink.
Ames. Spring on hillside. Buchanan.

98. *V. germinata* var. *racemosa* Walz.

Iowa City. Hobby.
Grinnell. Fink.
Ames. Buchanan.
Ames. Roadside puddle. Fawcett.

99. *V. terrestris* Lyngb.

Ames. Bessey.
Fayette. Fink.

Order VIII.

Conjugatae.

KEY TO THE FAMILIES.

Thallus multicellular ....I. Zygnemaceae
Thallus uni-cellular..................................II. Desmidiaceae

Family I.

Zygnemaceae.

KEY TO THE SUBFAMILIES.

Conjugation forming a zygospore which immediately develops a sporocarp of several cells, one of which is the spore (carpospore). The gametophyte is developed from this after a period of rest..............
....I. Mesocarpeae
Conjugation producing a zygospore which after a period of rest develops directly into a new gametophyte........................II. Zygnemeae

Subfamily I.

Mesocarpeae.

1. *Mougeotia.*

100. *M. genuflexa* Ag.

Fayette. Fink.

101. *M. scalaris* Hass.

Iowa City. Hobby.
Ames. Bessey.

Subfamily II.

Zygnemeae.

KEY TO THE GENERA.

Chlorophyll in stellate masses...........................1. Zygnema
Chlorophyll in spiral bands.............................2. Spirogyra

1. *Zygnema.*

KEY TO THE SPECIES.

Zygospore in one of the conjugating cells.
Intermediate membrane of spores smooth, 26-30 u broad....*Z. insigne*

Sporoderm punctate or granulate.
Cells 10-36 u in diameter.............................*Z. stellium*
Cells 35-50 u in diameter...........................*Z. cruciatum*
Zygospore between the conjugating cells..................*Z. pectinatum*

102. Z. insigne Kuetz.
Iowa City. Hobby.
Ames. Bessey.

103. Z stellinum Ag.
Eagle Grove. Floating in Hewitt's Pond. Buchanan.

104. Z. cruciatum Ag.
Iowa City. Hobby.
Eagle Grove. Hewitt's Pond. Buchanan.

105. Z pectinatum Ag.
Iowa City. Hobby.

2. *Spirogyra.*

KEY TO THE SPECIES OF SPIROGYRA.

Septa between cells smooth, not folded back or replicate.
Fruiting cells little or not at all swollen.
One spiral in each cell.
Zygospores spherical.
Vegetative cells 30-48 u wide.........................*S. porticalis*
Vegetative cells 30-32 u wide...................*S. porticalis alpina*
Zygospore oval to elliptical.
Broad oval, 1½-2½ times as long as wide.
18-28 u in diameter..................................*S. longata*
33-38 u in diameter..................................*S. varians*
Elliptical, 2-3 times as long as wide, 19-23 u in diameter............
....*S. communis*
Two or more spirals in each cell.
Zygospore ovoid or ellipsoid.
Vegetative filaments 33-40 u in diameter.
Cells 2-4 times as long as wide......................*S. decimina*
Cells 4-10 times as long as wide.....................*S. rivularis*
Vegetative cells more than 50 u in width.
Cells 54-78 u in diameter.............................*S. nitida*
Cells 86-110 u in diameter.
Cells 1½-2 times as long as wide..................*S. jugalis*
Cells ½-1 times as long as wide..................*S. setiformis*
Zygospore lens shaped or flattened .
Vegetative filaments 54-62 u in diameter...............*S. majuscula*
Vegetative filaments 70-160 u in diameter.
Zygospores 102-115 u in diameter.....................*S. maxima*
Zygospores 144-15 u in diameter.......................*S. crassa*
Fruiting cells distinctly swollen.
One spiral in each cell.....................................*S. intermedia*
More than one spiral in each cell.
Two spirals.
Dense, close 3-4 turns...................................*S. adnata*
Looser, 2-3 turns...*S. dubia*
Four spirals. Cells 35-40 u wide.......................*S. fluviatilis*

Septa between the cells folded back, replicate.
  Membrane of Zygospore smooth.
    One (rarely two) spirals in a cell.
      Vegetative cells 8-12 u in diameter........................*S. tenuissima*
      Vegetative cells 13-18 u in diameter........................*S. inflata*
      Vegetative cells 11 u or more in diameter.
        Diameter Zygospores 26-30 u..............................*S. weberi*
        Diameter Zygospores 30-33 u..............................*S. laxa*
        Diameter Zygospores 20-33 u..............................*S. grevilleana*
        Diameter Zygospores 40-48 u..............................*S. quadrata*
    Three spirals in a cell....................................*S. insignis*
  Membrane of the Zygospore areolate or punctate..............*S. calospora*

106. S. *porticalis* Cleve. *(S. quinina).*
Iowa City. Hobby.
Ames. Bessey.
Eagle Grove. Hewitt's Pond. Buchanan.

107. S. *porticalis* var. *alpina* Kuetz.
Iowa City. Hobby.

108. S. *longata* Kuetz.
Iowa City. Hobby.
Ames. Bessey.
Eagle Grove. Pond. Buchanan.

109. S. *varians* Kuetz.
Iowa City. Hobby.

110. S. *communis* Kuetz.
Iowa City. Hobby.

111. S. *decimina* Kuetz.
Iowa City. Hobby.
Eagle Grove. Pond. Buchanan.

112. S. *rivularis* Rabenh.
Iowa City. Hobby.

113. S. *nitida* Link.
Iowa City. Hobby.
Eagle Grove. In pond among lily pads. Buchanan.

114. S. *jugalis* Kuetz.
Eagle Grove. Floating in Hewitt's Pond. Buchanan.

115. S. *setiformis* Kuetz.
Eagle Grove. Jenning's Pond. Buchanan.

116. S. *majuscula* Kuetz.
Iowa City. Hobby.
Ames. Bessey.
Eagle Grove. Hewitt's Pond. Buchanan.

117. S. *maxima* Wittr.
Eagle Grove. Jenning's Pond. Buchanan.

118. S. *crassa* Kuetz.
Iowa City. Hobby.

119. S. *intermedia* Rabenh.
Iowa City. Hobby.

120. S. *adnata* Kuetz.
Iowa City. Hobby.

121. *S. dubia* Kuetz.

Iowa City. Hobby.

122. *S. fluviatilis.* Hilse.

Iowa City. Hobby.

123. *S. tenuissima* Kuetz.

Eagle Grove. Slough, amid Utricularia. Buchanan.

124. *S. inflata* Rabenh.

Iowa City. Hobby.

125. *S. weberi* Kuetz.

Iowa City. Hobby.

126. *S. laxa* Kuetz.

Iowa City. Hobby.

127. *S. grevilleana* Kuetz.

Iowa City. Hobby.

Eagle Grove. Floating in Hewitt's Pond. Buchanan.

128. *S. quadrata* Petit.

Ames. Buchanan.

Eagle Grove. Buchanan.

129. *S. insignis* Kuetz.

Iowa City. Hobby.

130. *S. calospora* Cleve. *(S. protecta).*

Ames. Bessey.

Eagle Grove. Jenning's Pond. Buchanan.

Family II.

Desmidiaceae.

KEY TO THE SUBFAMILIES.

Cell wall unsegmented. Point of division of cells indefinite, and unknown previous to the actual division....................I. Sacodermae

Cell wall segmented. Cell division of a fixed type, with interpolation of the younger halves between the old ones................II. Placodermae

Subfamily I.

Saccodermae.

1. *Spirotaenia.*

131. *S. condensata* Breb.

Eagle Grove. Slough. Buchanan.

Subfamily II.

Placodermae.

KEY TO THE TRIBES.

Cells of moderate length, straight, cylindrical, sometimes with a slight median constriction. Cell wall with or without pores. Point of division of cells often variable. The cell often arrives at maturity by periodical *growth* ....I. Penieae

Cells elongate, generally curved; symmetrical in one longitudinal plane only. Cell wall commonly with pores. Points of division regularly placed in the middle region of the cell..................II. Closterieae

Cells exhibit a great variety of form, and the cell wall consists of two thin, firm layers with pores. There is no periodical growth, the cell becoming adult immediately after division by the mature growth of the semi-cell ....III. Cosmarieae

Tribe I.

Penieae.

1. *Penium.*

132. *P. closterioides* Ralfs.

East Okoboji, in stagnant pool by water's edge. Buchanan.

Ames. Roadside pool. Buchanan.

Tribe II.

Closterieae.

1. *Closterium.*

KEY TO THE SPECIES.

Cells more or less cylindrical, slightly bent, ends scarcely or not at all tapering. Diameter, 50-55 u..........................*C. lanceolatum*

Cells slightly bent, back or dorsum slightly convex, opposite almost straight, distinctly tapering.

Diameter cells 35-62 u................................*C. acerosum*

Diameter cells 80-110 u................................*C. lunula*

Cells more or less curved, dorsal and ventral margins both convex, arched in the same direction, ends sensibly tapering, lunate.

Diameter cell 14 u....................................*C. jenneri*

Diameter cell 18-25 u..................................*C. dianae*

Diameter cell 25-28 u..............................*C. acuminatum*

Cells falcate incurved, ventral margin swollen, ends sensibly tapering, 36-55 u in diameter................................*C. moniliferum*

133. *C. lanceolatum* Kuetz.

Iowa City. Hobby.

134. *C. acerosum* Ehrenb.

Eagle Grove. Jenning's Pond. Buchanan.

Eagle Grove. Hewitt's Pond. Buchanan.

135. *C. lunula* Nitzsch.

Iowa City. Hobby.

136. *C. jenneri* Ralfs.

Eagle Grove. Jenning's Pond. Buchanan.

Eagle Grove. Slough. Buchanan.

137. *C. dianae* Ehrenb.

Eagle Grove. Slough, amid Utricularia. Buchanan.

138. *C. acuminatum* Kuetz.

Eagle Grove. Slough, amid decaying rushes. Buchanan.

139. C. moniliferum Reinsch.

Ames. Bessey.
Ames. Stagnant pool, by railroad. Buchanan.
Eagle Grove. Stagnant pool by railroad. Buchanan.
Eagle Grove. In barrel for fire protection. Buchanan.
Eagle Grove. Slough. Buchanan.
Eagle Grove. Jenning's Pond. Buchanan.

Tribe III.

Cosmariae.

KEY TO THE GENERA.

Cells elongated and cylindrical; constriction slight.
  Base of semi-cells plicate..................................1. Docidium
  Base of semi-cells plane..................................2. Pleurotaenium
Cells relatively short, commonly depressed or radiating, constriction usually deep.
  Cells compressed (at right angles) to the plane of the front protuberance moderately lobed ....3. Euastrum
  Cells very compressed and deeply lobed or incised........4. Micrasterias
  Cells with a more or less entire margin, often furnished with warts or spines.
    Cell wall smooth, granulate, verrucose, etc. Central protuberance present or absent ....5. Cosmarium
    Cell wall with regularly arranged spines, commonly in pairs. Central protuberance always present..........................6. Xanthidium
    Cell wall without central protuberance with spines....7. Arthrodesmus
    Cells from the vertical view commonly radiating triangular, quadrangular up to 11 radiate..............................8. Staurastrum

1. *Docidium.*

140. D. Baculum Breb.

Ames. Pond. Buchanan.

2. *Pleurotaenium.*

141. P. trabeculae (Ehrenb.) Naeg.

Eagle Grove. Slough amid Utricularia. Buchanan.
Eagle Grove. Slough amid decaying rushes. Buchanan.

3. *Euastrum.*

142. E. binale (Turp.) Ralfs.

Eagle Grove. Slough. Buchanan.

4. *Micrastorias.*

143. M. truncata (Corda) Breb.

Eagle Grove. Slough. Buchanan.

5. *Cosmarium.*

KEY TO THE SPECIES.

Single chloroplast (with one pyrenoid) in semi-cell.
  Semi-cell semi-orbicular..*C. leve*
  Semi-cell subquadrate, six angled...............*C. meneghinii concinnum*

Two chloroplasts (with two pyrenoids) in each semi-cell.
Membrane smooth or lightly punctate.
Nine crenae to semi-cell.............................*C. undulatum*
Ten-fourteen crenae to semi-cell............*C. undulatum crenulatum*
Membrane verrucose, rarely heavy punctate.
End of semi-cells broadly rounded..................*C. margaritiferum*
End of semi-cells truncate.
Diameter 35-62 u....................................C. botrytis
Diameter 25-30 u....................................*C. notabile*

144. *C. leve* Rabenh.
Fayette. Fink.

145. *C. meneghinii* var. *concinnum* Rabenh.
Eagle Grove. Slough. Buchanan.

146. *C. undulatum* Corda.
North Gar Lake. Buchanan.

147. *C. undulatum* var. *crenulatum.*
Eagle Grove. Slough. Buchanan.

148. *C. margaritiferum* Menegh.
Ames. Bessey.

149. *C. botrytis* Menegh.
Iowa City. Hobby.

150. *C. notabile* Hansg.
Eagle Grove. Slough, amid Utricularia. Buchanan.
Eagle Grove. Slough, decaying rushes. Buchanan.

6. *Xanthidium.*

151. *X. antilopaeum* Kuetz.
Eagle Grove. Slough. Buchanan.

7. *Arthrodesmus.*

152. *A. Incus* (Breb.) Hass.
Eagle Grove. Slough. Buchanan.

8. *Staurastrum.*

KEY TO SPECIES.

Very small, diameter 16-25 u.............................*S. pygmaeum*
Larger.
End view circular.................................*S. margaritaceum*
End view triangular...............................*S. polymorphum*
End view 4-6 angled...............................*S. crenulatum*

153. *S. pygmaeum* Breb.
Eagle Grove. Slough amid Urticularia. Buchanan.

154. *S. margaritaceum* Menegh.
Eagle Grove. Slough. Buchanan.

155. *S. polymorphum* Breb.
Eagle Grove. Slough amid Utricularia. Buchanan,
Eagle Grove. Slough amid decaying rushes. Buchanan.

156. *S. crenulatum* (Delp) Naeg.
Eagle Grove. Slough amid Urticularia. Buchanan.

Order IX.

Protococcoideae.

KEY TO FAMILIES.

Unicellular or multicellular, sometimes pseudoparenchymatous. Some or all of the cells furnished with hairs or bristles, either simple or sheathed and often mucous. Multiplication by division of cells in two directions. Reproduction by two or four ciliated gametes................I. Chaetopeltidae
Unicellular or consisting of a definite coenobium of cells, which are either united by protoplasmic processes or enclosed within the swollen mucous mother cell wall. All the cells are ciliated and motile in their vegetative stage ....II. Volvocaceae
Unicellular, cells solitary, differentiated into base and apex, epiphytic on other algae; chloroplast parietal with one pyrenoid. No vegetative division. Reproduction solely by zoogonidia formed by successive divisions of the contents of a mother cell.............................III. Characieae
Unicellular and globular, or of short ramified few celled filaments, never attenuated into hairs; often, pseudoparenchymatous. Chloroplasts one or several, parietal, with or without pyrenoids. Multiplication by division in two or three directions, and more rarely by zoogonidia. Cell wall very firm ....IV. Pleurococcaceae

Family I.

Chaetopeltideae.

1. *Chaetosphaeridium.*
157. *C. globosum* (Nordst) Klebahn.
Eagle Grove. Pond. Buchanan.

Family II.

Volvocaceae.

KEY TO SUBFAMILIES.

Unicellular, not united into coenobia................I. Chlamydomonadeae
Cells united into coenobia.......... ....II. Volvoceae

Subfamily I.

Chlamydomonadeae.

1. *Chlamydomonas.*
158. C. DeBaryana Gorosch.
Ames. In a puddle after rain. Buchanan.

Subfamily II.

Volvoceae.

KEY TO THE GENERA.

Coenobium flat, 16 cells.....................................1. Gonium

enobium spherical.
Of eight to thirty-two cells.
Isogamous ....2. Pandorina
Heterogamous ....3. Eudorina
Of several thousand cells..4. Volvox

Gonium.

G. pectorale Muell.

Ames. Bessey.
Ames. Aquarium. Buchanan.
Ames. Rain water pond. Buchanan.

Pandorina.

P. morum (Muell) Bory.

Ames. Bessey.
Ames. Aquarium. Buchanan.
Ames. Near Ontario in pond. Buchanan.

Eudorina.

E. elegans Ehrenb.

Fayette. Fink.

Volvox.

2. *V. globator* (L.) Ehrenb.

Iowa City. Hobby.
Ames. Bessey.
Ames. Spring. Buchanan.
Fayette. Fink.
Eagle Grove. Jenning's Pond. Buchanan.
Lower Gar Lake. Buchanan.

Family III.

Characieae.

Characium.

1. *C. naegelii* A. Br.

Eagle Grove. Pond near R. R. Buchanan.

Family IV.

Pleurococcaceae.

Pleurococcus.

4. *P. vulgaris* Menegh.

Ames. Bessey.
Fayette. Fink.
Grinnell. Fink.
Ames. Buchanan.
Eagle Grove. Buchanan.

Family V.

Hydrodictyaceae.

KEY TO THE SUBFAMILIES.

Coenocytes arranged in form of a net...................I. Hydrodictyeae
Coenocyte arranged in a flat plate........................II. Pediastreae

Subfamily I.

Hydrodictyeae.

Hydrodictyon.
165. H. reticulatum (L.) Lagerh.
Iowa City. Hobby.
Forest City. Common Lime Creek. Shimek.
Sioux City. A. E. Paddock.
Cedar Falls. Buchanan.
Fayette. Fink.

Subfamily II.

Pediastreae.

1. *Pediastrum.*

KEY TO SPECIES.

Peripheral cells with two points..............................*P. boryanum*
Peripheral cells with four points...........................*P. ehrenbergii*
166. P. boryanum (Turp.) Menegh.
Ames. Bessey.
Eagle Grove. Slough, amid Utricularia. Buchanan.
167. P. ehrenbergii A. Br.
Eagle Grove. Slough, several collections. Buchanan.

Family VI.

Protococcaceae.

KEY TO THE SUBFAMILIES.

Cells elongated, often greatly attenuated and frequently curved. Solitary or loosely associated in colonies. One chloroplast per cell.......I. Selenastreae
Cells globose, ellipsoid or reniform or sublunate. Daughter cells retained in mother cell wall, Several chloroplasts to the cell............II. Oocystideae
Cells solitary, flattened and angular, with a definite number of angles, or polyhedral. Angles generally furnished with simple or furcate spines...... ....III. Tetraedrieae

Subfamily I.

Selenastreae.

KEY TO THE GENERA.

Cells ellipsoid or much attenuated, forming more or less definite colonies consisting of a row of cells in one plane......................1. Scenedesmus

Cells elongate and acutely attenuated, often lunate, solitary or loosely grouped in irregular bundles. Cells of moderate length, usually with not more than one pyrenoid ....2. Ankistrodesmus

Scenedesmus.

KEY TO THE SPECIES.

Cells obtuse rounded at each pole.
  No cells with hairs or spines..............................*S. bijugatus*
  Terminal cell with a hair on each pole.....................*S. quadricauda*
Cells usually acute at both ends..........*S. obliquus—S. obliquus dimorphus*

168. *S. bijugatus* (Turp.) Kuetz.
Eagle Grove. Slough, amid Utricularia. Buchanan.

169. *S. quadricauda* (Turp.) Breb.
Fayette. Fink.
Grinnell. Fink.
Ames. Bessey.

170. *S. quadricauda* var. *abundans.*
Fayette. Fink.
Grinnell. Fink.

171. *S. obliquus* Kuetz.
Fayette. Fink.
Grinnell. Fink.
Ames. Aquarium. Buchanan.

172. *S. obliquus* var. *dimorphus* Rabenh.
Fayette. Fink.
Grinnell. Fink.
Aquarium, Ames. With peat from northern Iowa. Buchanan.

2. *Ankistrodesmus (Rhaphidium).*

KEY TO THE SPECIES.

Cells 16-24 times as long as broad.
  Chloroplast without pyrenoid..............................*A. falcatus*
  Chloroplast with pyrenoid..........................*A. falcatus aciculare*
Cells 3-6 times as long as broad............................*A. convolutus*

173. *A. falcatus* (Corda) Ralfs *(R. polymorphum).*
Fayette. Fink.
Grinnell. Fink.

74. *A falcatus* var. *acicularis* (A. Br.) West.
Fayette. Fink.
Boone. Horse trough. Buchanan.
Eagle Grove. Slough. Buchanan.

'5. *A. convolutus* (Rabenh.) West.
Fayette. Fink.

Subfamily II.

Oocystideae.

Palmellococcus.

6. *P. miniatus* (Kuetz.) Chodat.
Ames. Under limestone arch, College. Buchanan.

Subfamily III.

Tetraedrieae.

1. *Tetraedron.*

177. ***Tetraedron longispinum*** **(Perty) Hausg.**
Ames. Bed of Creek below filter beds. Buchanan.

Family VII.

Palmellaceae.

KEY TO THE SUBFAMILIES.

Cells irregularly grouped in a structureless mass of mucus.....I. Palmelleae
Cells grouped in four or sometimes irregularly disposed at the periphery of a structureless mass of mucus. Each cell with two pseudocilia...II. Tetrasporeae
Cells grouped in twos or fours within a lamellose mucous investment..III. Gloeocystideae

Subfamily I.

Palmelleae.

1. *Palmella.*

178. *P. mucosa* Kuetz.
Boone. Ledges. In slow stream. Buchanan.

Subfamily II.

Tetrasporeae.

1. *Tetraspora.*

179. *T. lubrica* Ag.
Iowa City. Hobby.
Ames. Bessey.
Boone. Ledges. Buchanan.
Ames. College spring. Buchanan.

180. *T. gelatinosa* (Vauch) Desv.
Iowa City. Hobby.

Subfamily III.

Gloeocystideae.

1. *Gloeocystis.*

181. *G. gigas* (Kuetz) Lagorh.
Ames. Buchanan.

DISTRIBUTION OF THE ALGAE IN GENERAL. Although conditions in Iowa are not generally suitable for the development of a large number of species of algae, yet there have been to date one hundred eighty species described as found within the state. Some of these forms are very local in their distribution, others are found everywhere.

One of the groups of algae having the widest and most general distribution is undoubtedly the Diatomaceae. When these are finally worked up for the state there will undoubtedly be found several hundred of species at least. They are found everywhere, on moist soil in stagnant and running water, wherever there is a fair and constant supply of moisture.

Next in abundance to these forms come the blue green algae or Myxophyceae. These are found likewise ubiquitously. Although their total number of species is not as great as some of the other groups, undoubtedly they surpass the remainder many times over in actual number of individuals.

The genus Spirogyra with twenty-five reported species is the largest with respect to number of species, although it is believed that some of the genera of Desmids will become a close second on a further study of the flora of some sections of the state. It has frequently been stated that the Desmids are not found in numbers in the state. This certainly is not true of the marshy districts in the northern part of the state where in one collection some thirteen species of desmids were secured. These, however, are very local in their distribution. Undoubtedly these sloughs in the northern counties of the state contain a very rich desmid flora, especially those that consist largely of peat.

Some of these algae are of some little importance in that they grow upon the mud along streams, sometimes in dense mats shading the ground, and retaining the moisture and making possible the existence of phanerogamic flora which could not exist otherwise.

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HOMOLOGY OF TISSUES IN FERNS.

BY HENRY S. CONARD.

In comparing two or more organisms our standpoint may be developmental, morphological or physiological. Or, we may strike a middle ground in what is called the morpho-physiological point of view.

Morphology and development agree in using the word *homology* to designate the relation between two organs which have a similar origin in the development of the individual, i. e., in ontogeny. For such organs we freely assume a common phylogenetic origin. An example of this is the relation of the spore mother cell of a moss to the pollen-spore mother cell of a flowering plant. They are homologous organs. Purely physiological similarities are termed by common consent *analogies*. The relation between a tendril of a pea and that of the grape is only analogy. One is a modified leaflet, the other a modified shoot. The two organs have nothing in common either in ontogeny or phylogeny, save the common irritability of their living substance.

In all of the higher plants, however, there is continual new growth of organs from embryonic or meristem tissues. Thus a kind of serial homology is found, similar parts being successively formed anew in the growing regions. In such cases we find that the morpho-physiological basis of comparison is the truer one, and leads to sound phylogenetic conclusions. It is my intention to demonstrate this by reference to the structure and development of fern-plants (Pteridophytes).

First we shall see that similarity or difference in the origin of tissues from the apical cell or primitive meristem *(Urmeristem* of Haberlandt) is, in many instances, of no significance. It is well known that the roots, stems and leaves of ferns are traversed by continuous vascular tissues which serve to convey and distribute the sap, and that the details of these tissues are similar in whatever organ they are found. The endodermis, phloem and xylem are perfectly distinct and homogeneous tissues. The epidermis also is, in most ferns, a continuous tissue all over the exterior of the plant. Only at the growing points are these tissue relations interrupted.

Are these tissues homologous throughout the various organs of the individual and in different individuals and species?

Every cell of the root takes its origin from a single apical cell which is shaped like a three-sided pyramid, and cuts off segments on all four faces. Every cell of the stem originates from a similar apical initial which cuts off segments on three faces. The young leaf has for a time a similar tetrahedral initial with three planes of division, then the initial becomes "two-sided," and after the rudiments of eight to eleven pinnae are established (in *Dennstaedtia punctilobula)* the single initial is replaced by a group of apical initials of equal rank. Therefore, since each organ has its own type of initial, or may have several types in the course of its development, it is plain that the relation of a given tissue, the xylem for example, to the apical cell cannot form a final basis of homology.

However, the apical cell or cells do not give rise at once to permanent tissues. They form rather an embryonic tissue, the primary meristem of Haberlandt, out of which the permanent tissues are gradually moulded. Now, in the leaf of *Dennstaedtia punctilobula* (Boulder Fern; Hay-scented Fern) the primary meristem may come from a two-sided initial, or from a group of marginal initials. Similarly, in the stems of true ferns (Filices), Marattiaceae and Cycads primary meristems arise from a single tetrahedral cell, or from a group of initials. But as no one questions the close phyletic relationship of these three groups, neither can we question the essential homology of their primary meristems. The origin of the primary meristems, therefore, need not figure in our discussion.

Can we draw any inferences, then, from the manner in which mature tissues arise from this primary meristem? Hanstein long ago observed in certain flowering plants an early division of the meristem into three concentric zones: (1) the plerome or central portion which gives rise to the pith and vascular tissues; (2) the periblem surrounding this, which gives rise to the cortex of the mature stem; and (3) the dermatogen on the outside, which is the embryonic epidermis. The division between plerome and periblem falls just inside the endodermis. A similar alignment of cells in the primary meristem occurs in the roots of ferns (Filices). But the line of division is different in stems and leaves of ferns (at least in *Dennstaedtia punctilobula)*, where the endodermis is the outermost layer of plerome. Must we, then, believe that the endodermis of roots is not homologous with that of the stem and leaves of the self-same plant? I cannot so believe. But it is on suc

morphological grounds that Campbell (Mosses and Ferns, 1905, p. 465) denies the homology of the vascular system of Equisetum with the central vascular strand of Sphenophyllum. He says of Equisetum, "the whole vascular system of the stem originates from the primary cortex or periblem, the original central tissue-cylinder giving rise only to the pith." The same arguments would apply in comparing the stems of Lygodium and Adiantum, or the very young and the mature individual of Dennstaedtia. That the vascular tissues of the individual fern are serially homologous follows from the observed facts of development. That they are phylogenetically homologous in different individuals and different species is indicated by the exact parallelism, pointed out first by Jeffrey and Boodle, between the ontogenetic and phylogenetic series. Hence any negative argument based on the origin of tissues in primary meristem must fall. The developmental viewpoint is manifestly a guide to phyletic relationship.

Shall we then be free to adopt the purely morphological basis, and consider similarity of structure equivalent to community of origin? By no means. The single initial cell of the moss *(Musci)* sporophyte, for example, has no direct relation to that of Equisetum or the leptosporangiate ferns. For if we can think of any ancestor of the pteridophytes among the byrophytes, it must be in the *Hepaticae* and not the *Musci*. But no living hepatic shows any well marked apical growth in the sporophyte. Therefore it is most probable that growth by a single initial has arisen independently in mosses and ferns. Again, in true ferns the cortical and medullary tissues often show striking resemblances. But ontogeny teaches us that they have very different histories. They may be truly considered as a unit, the fundamental tissue. But the parenchyma enclosed by the vascular ring is no more to be called cortex than is that outside to be called medulla. Hence a strict morphological basis of homology is not tenable.

So we must come back finally to the conclusions which follow at once from morpho-physiological considerations. Those tissues are homologous whose form, function and position in the organism point to a common origin. And we may safely say that the normal primary vascular tissues of all vascular plants are truly homologous.

A STUDY OF THE VARIATION OF THE NUMBER OF RAY FLOWERS OF CERTAIN COMPOSITAE.

BY WINFIELD DUDGEON.

The study of the variation of the ray flowers of *Rudbeckia hirta* (cone flower) was taken up during the Summer of 1906, at the suggestion of Dr. L. H. Pammel. The object of the study was to determine the amount of variation of the ray flowers, the variation for different localities, and any other facts that could be determined. Later, a study of *Rudbeckia triloba* and *Helianthus grosse-serratus* was taken up, with the same end in view, and that the different species might be compared.

In all, 5,885 heads were counted, with a distribution as follows:

TABLE No. 1.

DISTRIBUTION OF THE HEADS COUNTED.

Flower	No. Heads	Locality	Collected by	Date
Rudbeckia hirta	3,847	Total	....	....
	558	Ames, Ia.	E. R. Garner and writer	Aug., Sept.
	128	Center Point, Ia.	D. C. Snyder	Aug.
	3,161	8 miles southeast of Hedrick, Ia.	Writer	July, Aug.
Rudbeckia triloba	742	Ames, Ia.	Class in Evolution of Plants	Sept.
Helianthus grosse-serratus	1,296	Total	....	....
	125	Council Bluffs, Ia.	....	Sept.
	1,171	Ames, Ia.	Class in Evolution of Plants	Sept., Oct.

All of the heads of *Rudbeckia hirta* were counted by the writer. The heads of *Rudbeckia triloba* and *Helianthus grosse-serratus* were counted by a class in Evolution of Plants, at Iowa State college. Some of the *Rudbeckia hirta* plants grew in a dry, light, sandy soil, in a closely cropped pasture. All of the other plants grew in from average to good conditions.

All of the heads were taken at random. No conscious selection was used. In nearly all cases, when a plant was taken, all of the

Rudbeckia hirta. Purple cone flower.

Helianthus grosse-serratus. **Meadow sunflower.**

flowers on it were counted. Only imperfect, and partially destroyed heads were discarded. Great care was taken in counting the rays, and in recording the counts, that no mistakes be made. Table No. 2 records the results of the counts.

TABLE No. 2.

CONDENSED TABLE FOR ALL THE VARIETIES STUDIED, SHOWING ALL OF THE MAGNITUDES AND THEIR CORRESPONDING FREQUENCIES.

Rays per head	Rudbeckia hirta				Rudb'kia triloba	Helianthus grosse-serratus		
	Ames	Center Point	Hedrick	Total	Ames	Council Bluffs	Ames	Total
2	....	....	1	1	....	....	....	....
3	....	....	1	1	....	....	....	....
4	....	1	2	3	....	....	....	....
5	....	....	18	18	20	....	....	....
6	1	4	19	24	83	....	....	....
7	4	5	52	61	192	....	1	1
8	45	1	576	622	306	....	1	1
9	36	9	294	339	91	....	13	13
10	42	9	249	300	32	2	27	29
11	53	21	233	307	11	6	65	71
12	87	23	340	450	4	16	124	140
13	230	47	1,050	1,327	1	34	320	354
14	43	5	192	240	2	23	215	238
15	12	3	59	74	....	21	143	164
16	2	....	35	37	....	10	76	86
17	....	....	12	12	....	7	51	58
18	1	....	5	6	....	4	41	45
19	....	....	9	9	....	2	26	28
20	1	....	1	2	....	....	25	25
21	....	....	4	4	....	....	35	35
22	....	....	4	4	....	....	7	7
23	....	....	3	3	....	....	....	....
24	....	....	....	....	....	....	....	....
25	....	....	1	1	....	....	1	1
26	....	....	....	....	....	....	....	....
27	1	....	....	1	....	....	....	....
28	....	....	1	1	....	....	....	....
Tot.	558	128	3,161	3,847	742	125	1,171	1,296

It will be seen by inspection of Table No. 2, and Plates I, II, III, and IV, that heads of *Rudbeckia hirta* containing 13 rays greatly predominate. The characteristic mode is at 13, with a very marked mode at 8, and smaller modes at 19 and 21-22. This very closely agrees with the results obtained by Lucas, '04 (Am. Nat., 38:427-429). He says that *Rudbeckia hirta* has a primary mode at 13, and secondary modes at 8 and 20-21. It is possible that a

larger number of variates in this study would have changed the secondary modes at 19 and 21-22 to a single mode at 20-21.

The *Rudbeckia hirta* heads from Ames do not have the mode at 19, and the mode at 8 is not so prominent. The heads from Center Point show a secondary mode at 7 only, but this irregularity is undoubtedly due to the small number of heads counted. The curve for the heads from Hedrick very closely resembles that for the total number of heads.

The curve for *Rudbeckia triloba* is very regular and smooth, with a mode at 8.

The curve for *Helianthus grosse-serratus* is somewhat irregular. The characteristic mode is at 13, with a small secondary mode at 21. It is probable that the secondary mode would disappear if more variates were counted. It does disappear if the classes are doubled, as is shown by Table No. 3 and Plate IX. In that

TABLE No. 3.

SHOWING THE COUNT FOR HELIANTHUS GROSSE-SERRATUS, WITH THE CLASSES DOUBLED.

Magnitudes....	7	8-9	10-11	12-13	14-15	16-17	18-19	20-21	22-23	24-25
Frequencies...	1	14	100	494	402	144	73	60	7	1

case, the mode is at 12-13. The curve for the heads from Council Bluffs has but one mode, that at 13. So few heads came from there, though, that the curve has but little significance. Because nearly all of the *H. grosse-serratus* heads came from Ames, the curve for that place is very similar to the curve for the total number of heads, having a characteristic mode at 13, and a secondary mode at 21. By doubling the classes, this secondary mode may be made to disappear, also.

The formulae for the computation of all the constants were taken from "Statistical Methods with Special Reference to Biological Variation," by Davenport, '04. Great care has been taken that no mathematical errors enter into the work. To this end, all of the calculations were carried out to five decimal places, although only four are given in this paper. As far as possible, all the work was very carefully checked.

The following formulae have been used:

$$A = \frac{\Sigma (v \cdot f)}{n}$$

where A = the mean or average, Σ = sign of summation, V = the magnitude of any class, f = the frequency, or number of varieties in that class, and n = the total number of varieties.

$$\sigma = \sqrt{\frac{\Sigma (X^2 \cdot f)}{n}} \cdot \lambda$$

where σ = index of variability, or the amount the group as a whole varies f the mean, X = the amount of the deviation of any class from the mean, λ = number of units in the class range. It is unity in all of these calculation

$$C = \frac{\sigma}{A} \cdot 100\%$$

where C = coefficient of variability. The 100% is to get the result into ı convenient form, and is entirely arbitrary.

$$E_A = \pm .6745 \cdot \frac{\sigma}{\sqrt{n}}$$

where E_A = the probable error of the mean.

$$E_D = \pm .6745 \cdot \frac{\sigma}{\sqrt{n}}$$

where E_σ = the probable error of the index of variability.

Tables 4, 5, and 6 show the constants as worked out for the v ous species and localities:

TABLE No. 4.

CONSTANTS FOR *Rudbeckia hirta.*

	Total	Ames	Center Point	Hedrick
n =	3847	558	128	3161
A =	11.3436	11.8889	11.5234	11.2401
D =	2.4379	2.0315	2.0765	2.5170
C =	21.4910%	17.0877%	18.0196%	22.3933%
E_A =	.0265	.0580	.1238	.0302
E_D =	.0187	.0410	.0875	.0214

TABLE No. 5.

CONSTANTS FOR *Rudbeckia triloba.*

	Ames
n =	742
A =	7.7345
σ =	1.2344
C =	15.9590%
E_A =	.0306
E_σ =	.0216

TABLE No. 6.

CONSTANTS FOR *Helianthus grosse-serratus.*

	Total	Council Bluffs	Ames
n =	1296	125	1171
A =	14.1937	13.9680	14.2178
σ =	2.4864	1.8371	2.5448
C =	17.5178%	13.1522%	17.8988%
E_A =	.0466	.1108	.0502
E_σ =	.0329	.0784	.0355

CONCLUSIONS.

From the foregoing, it is seen that there is quite a degree of uniformity of variation for plants of a given species, from different localities. Had the number of variates from each locality been larger, it is very probable that the variation for localities would have been still less.

Rudbeckia hirta and *R. triloba* are interesting when brought together in a study of this nature, because they are so closely related. In Gray's "Synoptical Flora of North America," Vol. I, Part II, 260-261, *R. hirta* and *R. triloba* are represented as very closely related to each other, and to *R. bicolor* and *R. subtomentosa*. It would be interesting to study the variation of these related species, presenting as they do, no marked structural differences. If the material were taken from the native habitats of the plants, many interesting facts might be brought out.

There is some indication of a tendency to the formation of two somewhat distinct species from *Rudbeckia hirta*. In the dry, unfavorable soil, the predominating number of rays was 8, while the predominating number in good soil was 13. In the poor soil, the plants were small, and many bore but a single head.

There also seems to be a tendency for the number of rays per head, of *Rudbeckia hirta*, to decrease, because the slope of the upper side of the frequency curve is steep, while the lower side is more gentle (Plate I).

The tendency seems to be for the number of rays per head, of *Rudbeckia triloba*, to decrease a little. It is probably almost stationary (Plate V).

The tendency seems to be for the number of rays per head, of *Helianthus grosse-serratus*, to increase. The lower side of the curve is quite steep, while the upper is a more gentle slope (Plate VI).

The results for *Rudbeckia hirta* in this study agree somewhat closely with those found by Lucas. Taking five groups, containing from 173 to 318 heads each, he found the means to be 14.188, 11.328, 11.868, 9.612, and 11.813. That all of his means are not very nearly 11.000, may be due to the small number of heads in each group. As has been indicated, the modes found in this study agree very closely with those indicated by him.

No account has been taken of the period of the flowering season that these heads were counted. Undoubtedly, heads blooming earlier would vary somewhat from those blooming later in the

season. Shull found such a variation in a white aster he studied to be quite marked (Amer. Nat., 36:111-152). The amount of variation, due to this cause, there would be in plants of this study cannot be told, for no record was kept for that purpose, but it would probably be considerable.

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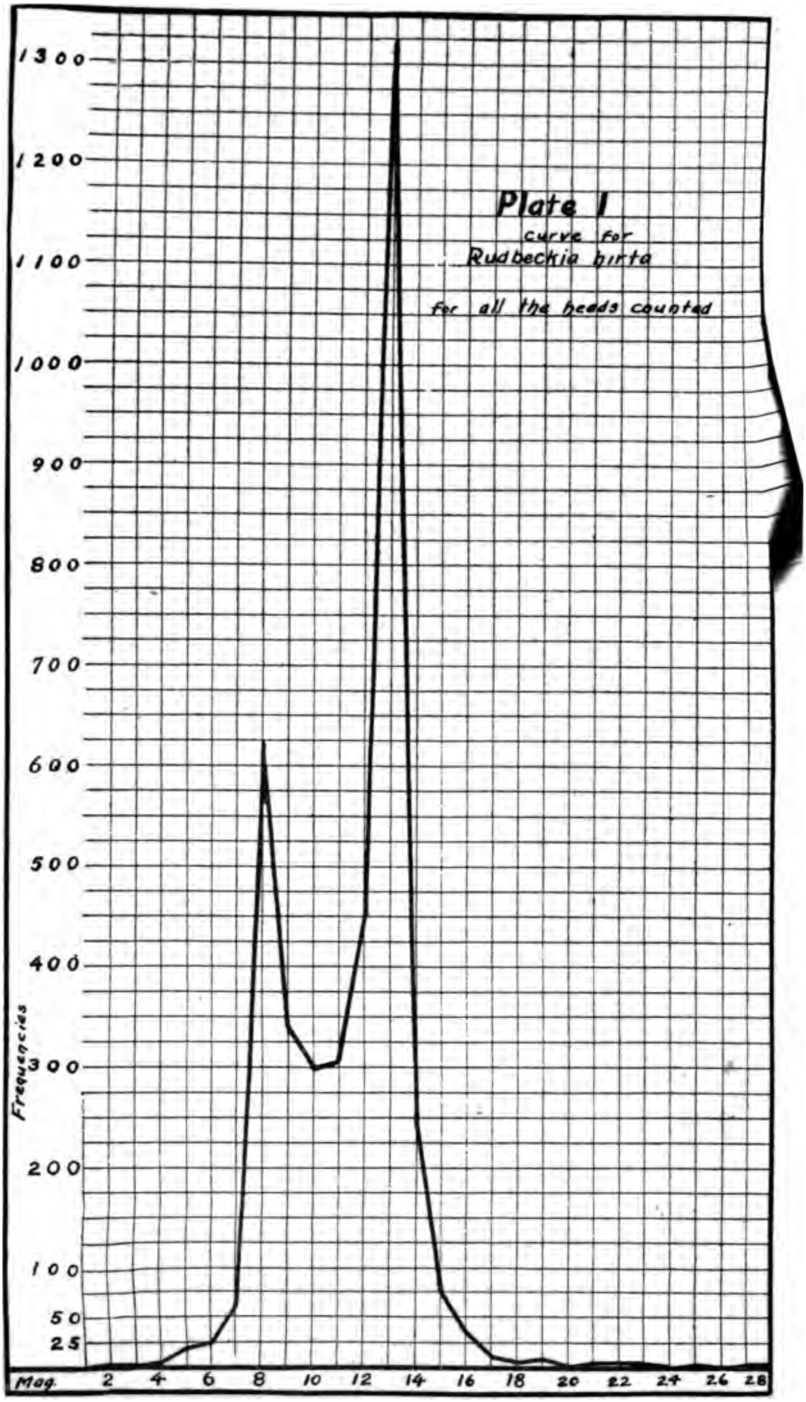


Plate I
curve for
Rudbeckia hirta
for all the heads counted
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
50
25
Frequencies
Mag.
2
4
6
8
10
12
14
16
18
20
22
24
26
28

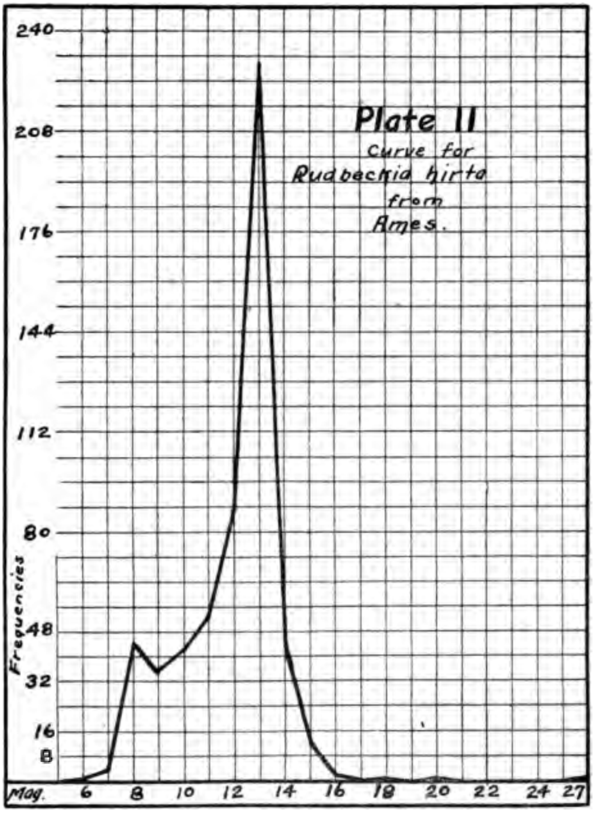


Plate II
Curve for
Rudbeckia hirta
from
Ames.
240
208
176
144
112
80
48
32
16
8
Frequencies
Mag.
6
8
10
12
14
16
18
20
22
24
27

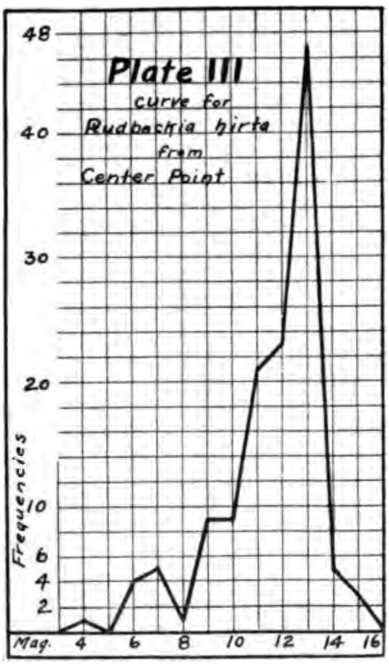


Plate III
curve for
Rudbeckia hirta
from
Center Point
48
40
30
20
Frequencies 10
6
4
2
Mag. 4 6 8 10 12 14 16

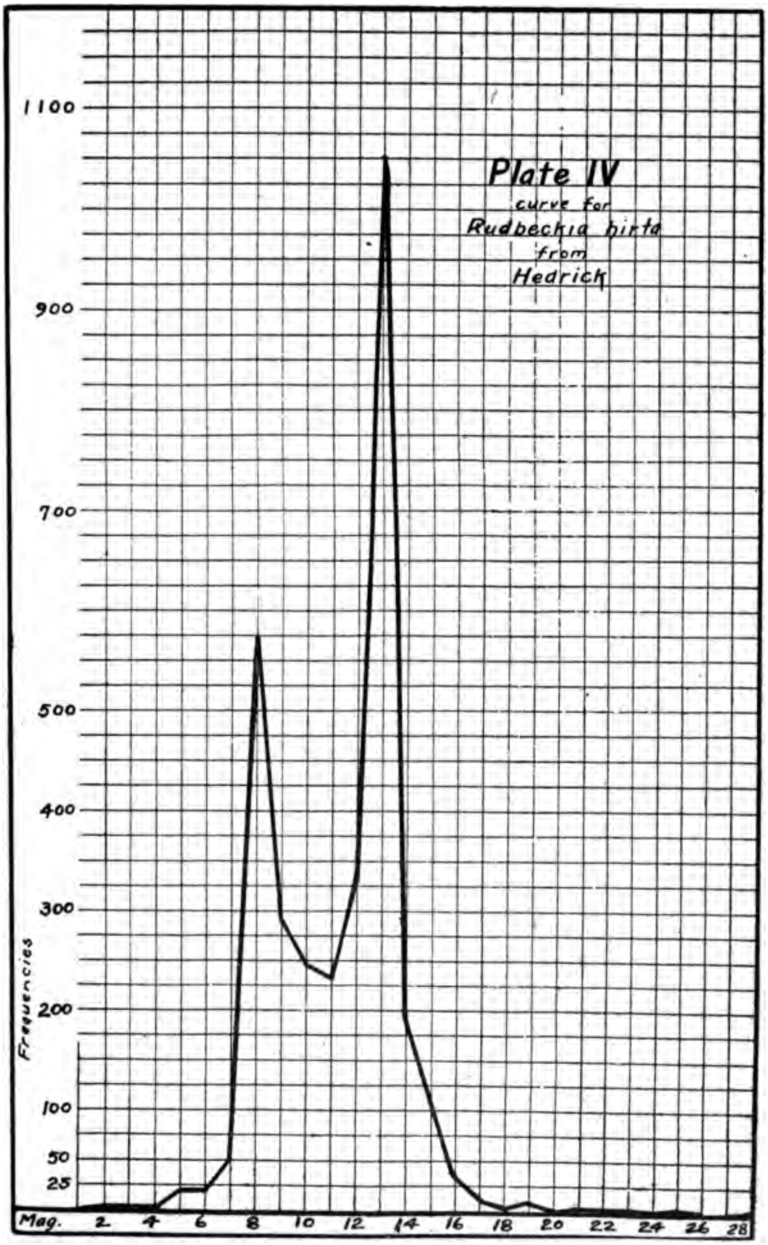


Plate IV
curve for
Rudbeckia hirta
from
Hedrick
1100
900
700
500
400
300
200
100
50
25
Frequencies
Mag.
2
4
6
8
10
12
14
16
18
20
22
24
26
28

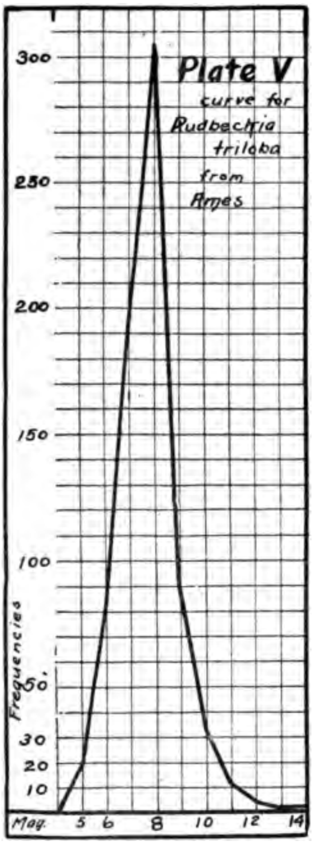


Plate V
curve for
Rudbeckia
triloba
from
Ames
300
250
200
150
100
Frequencies
50
30
20
10
Mag.
5
6
8
10
12
14

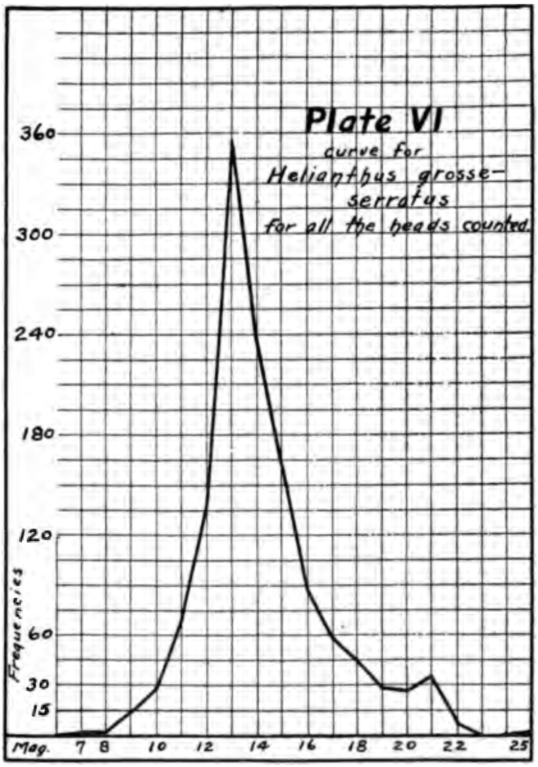


Plate VI
curve for
Helianthus grosse-
serratus
for all the heads counted.
360
300
240
180
120
60
30
15
Frequencies
Mag. 7 8 10 12 14 16 18 20 22 25

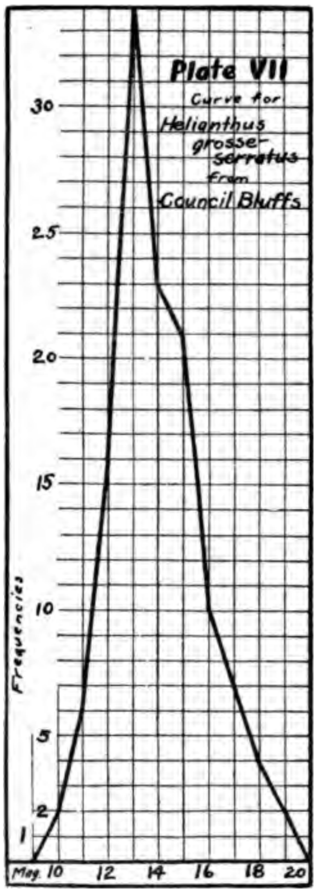


Plate VII
Curve for
Helianthus
grosse-
serratus
from
Council Bluffs
30
25
20
15
10
5
2
1
Frequencies
May 10
12
14
16
18
20

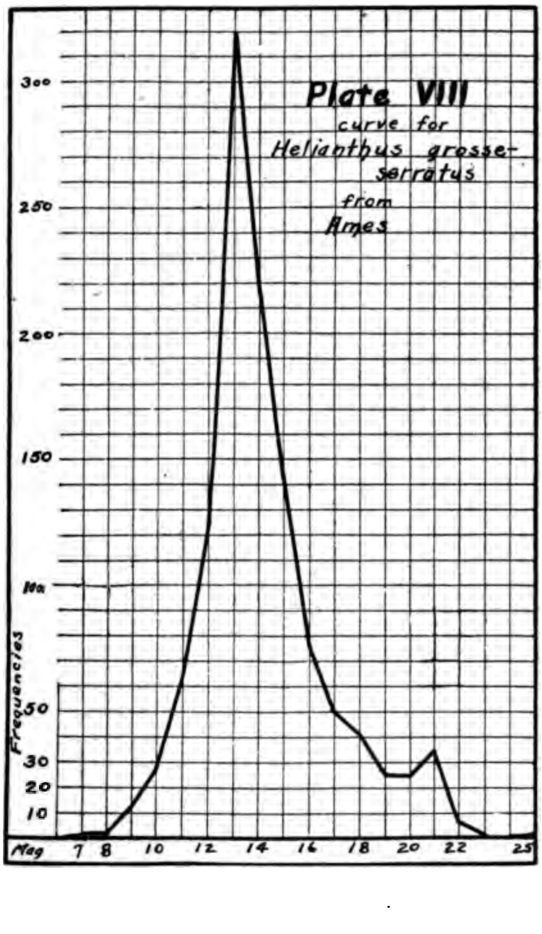


Plate VIII
curve for
Helianthus grosse-
serratus
from
Ames
300
250
200
150
100
Frequencies
50
30
20
10
May 7 8 10 12 14 16 18 20 22 25

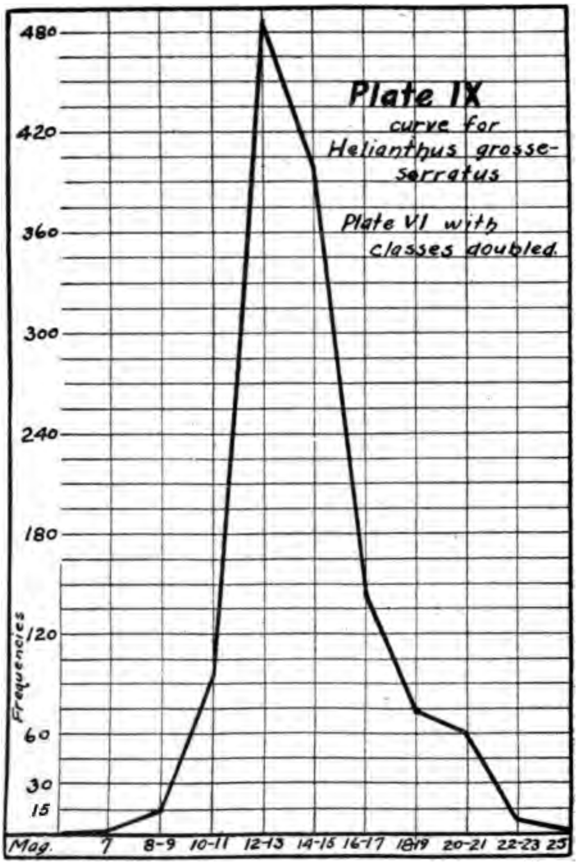


Plate IX
curve for
Helianthus grosse-
serratus
Plate VI with
classes doubled.
480
420
360
300
240
180
120
60
30
15
Frequencies
Mag.
7
8-9
10-11
12-13
14-15
16-17
18-19
20-21
22-23
25

STUDIES IN KARYOKINESIS.

BY JAMES ELLIS GOW.

The work whose results are here presented has been done at various times and places. The investigation of *Trillium* was undertaken at Blairstown during the fall and winter of 1905, and was carried on in the Botanical laboratory of the Blair Academy. Indian Corn and *Arisaema* were studied during 1901 and 1902 at the State University of Iowa, under the personal direction of Prof. T. H. Macbride, to whom are due thanks for the first suggestion leading to the undertaking, and for continued advice and assistance.

TRILLIUM SESSILE L.

Flower buds of *Trillium sessile,* cut in March, were killed and fixed in one per cent acetic acid and stained in Delafield's Haematoxylin. It was found that the sporogenous tissue was fully developed, the cells were in active division, and in some of the flowers the mother cells were breaking up into tetrads.

The earliest stage of division discoverable was that illustrated in Fig. 1. Careful search failed to reveal anything resembling the continuous spireme as figured by Schaffner in the onion and found by me in Indian corn. The chromatin first appears as a series of disconnected fragments in the surface of the nucleus. There is no evidence that it ever forms a continuous ribbon. The irregularity of arrangement does not indicate the presence of a ribbon composed of alternate areas of chromatin and linin, but rather a number of totally disconnected chromosomes. From the first the chromosomes show a tendency to split longitudinally, the process beginning at one end, and never, so far as observed, at both ends simultaneously. The normal number of chromosomes is twelve, which becomes six in the reduction division.

In the monaster, or mother star stage, the grouping of chromosomes about the spindle is very irregular. In many cases the chromosomes appear to adhere to the spindle by the middle, or by a point near the end, although this is difficult to determine. At all events, when the separation of the two halves begins, it does not proceed from the middle, but from one end. In the daughter star stage of division the chromosomes show considerable irregularity, with a general disposition to change their shape and assume a curved position as they approach the poles of the spindle. There is

nothing especially worthy of notice in the open and closed daughter skein stages and the formation of the cell plate.

In the preparations studied no trace of centrospheres could be observed. This does not prove their absence, for Delafield's Haematoxylin is not a good stain for such structures.

ARISAEMA TRIPHYLLUM (L.) TORR.

In studying the development of the embryo sac in this species, it was noticed that many of the vegetative cells in the base of the nucleus and the integuments were in active division. These were studied with the following results:

The first indication of nuclear division is the appearance of an irregular network of chromatin, as in figure 13. The strands gradually thicken and assume at the same time a more regular arrangement, until, in the spireme stage, the chromatin appears as a single continuous ribbon (Fig. 14). So far as the observation extended, the chromatin ribbon is always extremely irregular. No uniform number of loops could be observed. It shortly breaks up into sixteen chromosomes. No sign of early splitting of the chromosomes could be detected. After the formation of the spindle, the chromosomes assume a V-shaped form, each one adhering to the spindle fibers by its middle, the two ends being free. The splitting of the chromosomes begins at the apex of the V (the middle point of the chromosome), and extends thence to the ends, as represented in figure 19. The daughter star, stage, daughter skein, and formation of the cell plate, differ in no essential respect from the process as described in other plants. No centrospheres could be made out by the use of the 1-12 and 1-16 oil immersion objectives. The material was killed and fixed in chromo-acetic acid, imbedded in paraffin, cut to 3 micra on a Minot rotary microtome, and double stained with analin-water safranin and gentian violet.

ZEA MAYS L.

Kernels of Indian corn were sprouted in damp sand, and the root tips were cut off when an eighth to a quarter of an inch in length, killed and fixed in chromo-acetic acid, and sectioned by the paraffin method. The sections were stained in safranin-gentian-violet, Haematoxylin, Fuschin and Iodine Green, or Eosin.

While in the resting stage, the nucleus appears quite homogeneous, with a well defined nucleolus surrounded by a distinct hyaline area. The chromatin first appears as a continuous and extremely irregular ribbon. Before division the ribbon loops itself into eight

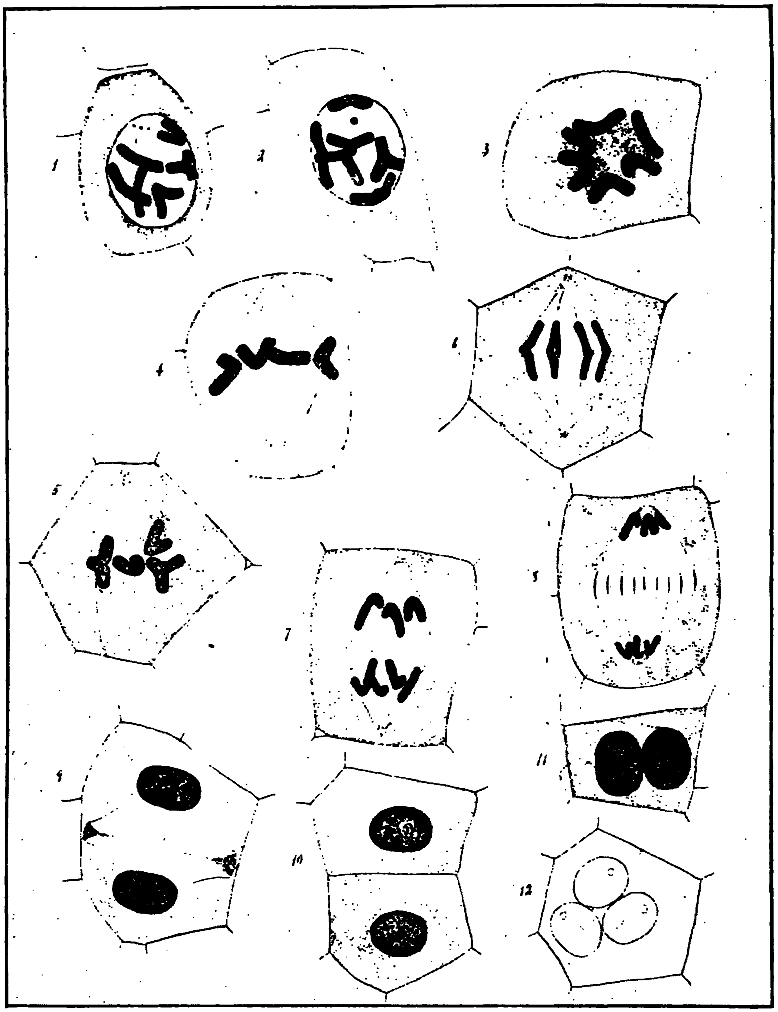
definite loops, which encircle the nucleus in somewhat regular fashion. The ribbon finally breaks up into sixteen distinct chromosomes, the breaks taking place at the apices of the loops. For a time the chromosomes frequently remain arranged equatorially about the nucleus, as in figure 31, but the arrangement is usually more irregular, as in figure 30. The beginning of the spindle is usually coincident with the breaking up of the chromatin ribbon and disappearance of the nucleolus, but such is not invariably the case. Frequently the nucleolus persists after the separation of the chromosomes, and in a few cases the spindle was observed to have become quite well defined before the disappearance of either the nuclear membrane or the nucleolus. As a general rule, however, it may be said that the breaking up of the chromatin ribbon is quickly followed by the disappearance of the nucleolus and the beginning of the spindle and the latter is quickly followed by or coincident with the disappearance of the nuclear membrane.

The prevalent opinion of botanists that the centrosome does not exist as an organ of the cell in vascular plants is so well accepted, and apparently so well grounded in fact that he would be a bold man who would dare dispute it. Certainly no such attempt will be made by myself, who am in the possession of no mass of data adequate to the formation of an independent conclusion upon such a subject. I have merely endeavored to reproduce as accurately as possible the appearance of the preparations I have studied, making no dogmatic assertion as to their meaning, but leaving others to attach any interpretation that may appear to them to be reasonable. The attraction spheres figured in numbers 35 to 40, are very doubtful. They appear very faintly in the original sections, and may be a part of the cytoplasm, which is granular and contains many bodies that might, in the proper position, be mistaken for centrospheres. Possibly the structures figured are merely such granular cytoplasmic bodies. On the other hand, in figures 33 and 34 appear distinct hyaline areas on the nucleus, each containing a small but deeply stained and well defined body, which appears to correspond closely to the centrosome, as it has been described. The nuclei in question are in very early prophase of division, which lends color to the supposition that the structures in question are in reality attraction spheres. If they are not attraction spheres, the question as to what they are is a rather difficult one to answer.

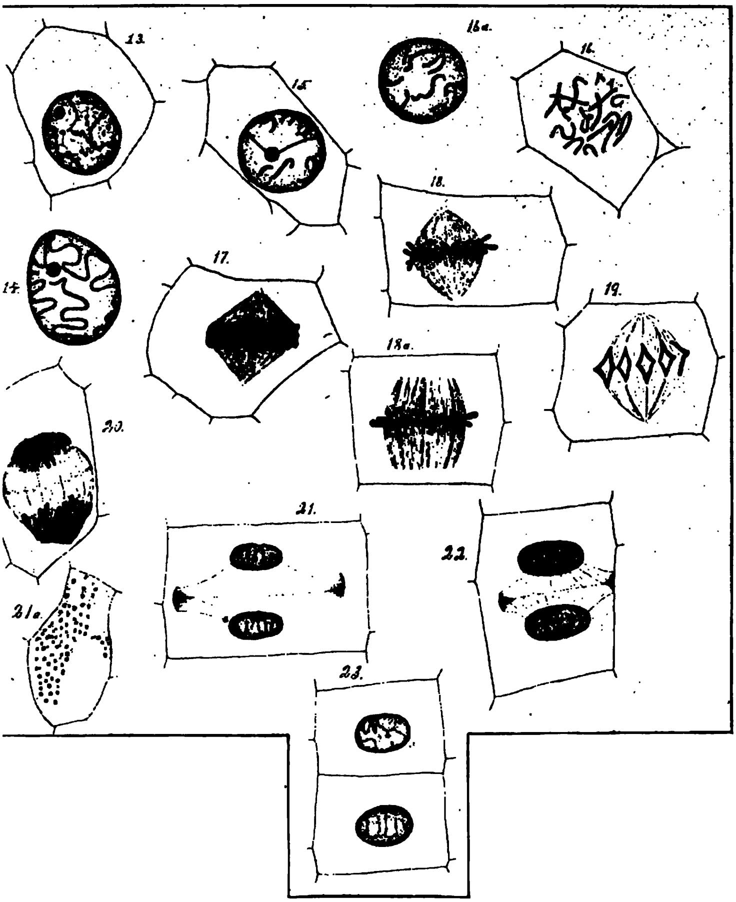
In the mother star stage, the chromosomes adhere to the spindle by their middles, each one assuming the shape of a V. Splitting begins at the apex of the V and continues outward to the ends. The daughter star and daughter skein stages and formation of the cell plate exhibit no unusual features.

EXPLANATION OF PLATES.

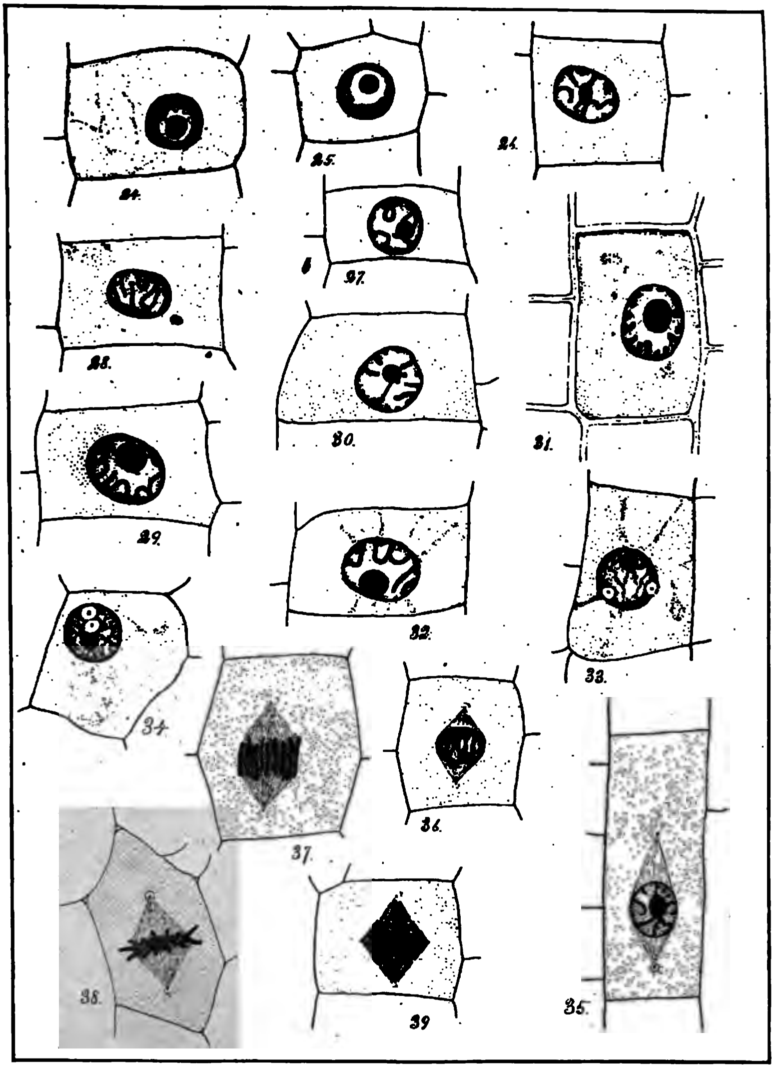
Figures 1 to 12 refer to *Trillium sessile*, 13 to 23 refer to *Arisaema triphyllum*, and 24 to 46 refer to *Zea Mays*.



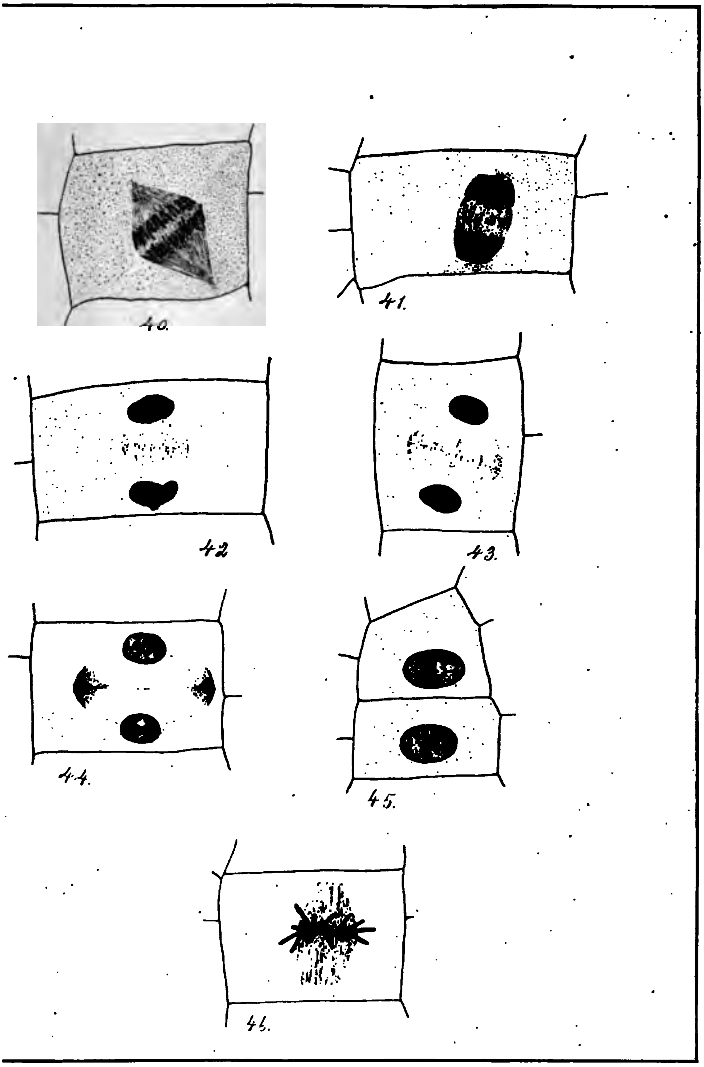
Figures 1 and 2. Late prophase in pollen mother cells of *Trillium*.
Figures 3, 4 and 5. Mother star stage. In 3 seen from pole of spindle.
Figures 6 and 7. Metakinesis.
Figure 8. Daughter star.
Figure 9. Daughter skein, and incipient cell plate.
Figure 10. Completion of division.
Figures 11 and 12. Multinucleate cells from tapetum.



re 13. Early prophase in vegetative cell of *Arisaema* showing chro-
ıetwork.
re 14. Continuous spireme.
res 15 and 15a. Separation of chromatin ribbon into 16 chromosomes.
ɔ figures show opposite surfaces of the same nucleus.
res 16 and 17. Disappearance of nuclear membrane. Chromosomes
l in nuclear plate, but not yet arranged on surface of spindle. Former
›lar, latter lateral.
res 18 and 18a. Mother star. Latter apparently multi-polar, due prob-
poor fixation.
re 19. Metakinesis.
re 20. Daughter star.
res 21 and 21a and 22. Formation of cell plate. Second view (21a)
ɔle, with nuclei cut away.
re 23. Completion of cell wall.



Figures 24 and 25. Resting nuclei in root tip of *Zea Mays*.
Figures 27, 28, 29 and 32. Continuous spireme.
Figures 26, 30 and 31. Formation of 16 chromosomes.
Figures 33 and 34. Early prophase, showing hyaline areas containi centrosomes.
Figures 35 and 36. Early formation of spindle before disappearance nuclear membrane. Rare and abnormal.
Figure 37. An abnormal spindle in which chromosomes fail to assume t typical V-shaped form.
Figure 38. Typical mother star.



39 and 40. Metakinesis.
41. Daughter star.
42. Daughter skein.
43 and 44. Incipient cell plate.
45. Completion of division.
46. Apparently multipolar spindle. due probably to poor fixation.

SOME MUNICIPAL WATER PROBLEMS.

BY L. H. PAMMEL.

One of the most important subjects engaging the attention of ities of various size in this country is a good, wholesome water upply, a supply which shall be free from those organisms which re responsible for certain diseases that may be classed with the reventable. In various parts of this country, efforts are being nade to supply the smaller cities with a good supply of water, and or this reason sewage disposal systems are being installed. The ublic has a right to demand that the water used for domestic purposes shall be of the best; it should jealously guard, therefore, the ource of supply. The water supplying our cities comes from the ollowing sources: rivers, lakes, mountain rivers, springs, and vells. Let us look for a moment at the sources of water supply. 'aking the streams that occur in Iowa, we find very few but what ollect a considerable amount of material that is undesirable in vater. On such a large stream as the Mississippi, there are loated the important cities of Keokuk, Burlington, Davenport, Rock sland, Muscatine, Clinton, and Dubuque. The water of this stream as many chances of pollution, especially so because people are not areful with reference to the discharge of waste matter and sewage nto the streams. For this reason, some of these cities have been orced to not only filter their water, but rely on deep wells. Davenort is an illustration where an efficient filter system eliminates nost of the injurious organisms, and we find from the records made y Mr. M. T. Evinger and W. L. Fulton that the average of Missisippi River water at Burlington contains 48,000 organisms; the iltered water contains 640 organisms. At Davenport, the Missisippi river contains 90,000 organisms, and the filtered water 2,800 rganisms. It will be seen that the Burlington filtration plant elimnates 98.9 per cent organisms, and at Davenport 96.9 per cent rganisms. We have here an efficient filtration system. It has ikewise been shown for the city of Albany, New York, where there vas a particularly high death rate of typhoid fever; that filtration liminates most of the bacteria. The present water supply of Albany comes directly from the Hudson River, passes into a small conrete structure, into the pumping station, then into a sedimentation asin, thus becoming aerated. The water is thus allowed to purify tself, and later passes through filters of gravel of three grades.

From the results of Mr. Allen Hazen's work, it appears that the unfiltered water from the Hudson River on Sept. 29th had 11,545 bacteria per cubic centimeter, filtered 608; Sept. 16th, unfiltered 1,483, filtered 306; Sept. 23d, unfiltered 17,403, filtered 273; Sept. 30th, unfiltered 22,600, filtered 259. It will thus be seen that the storage of water in the reservoir, and the later filtration have done away with a large number of organisms, and that it has very materially reduced the death rate of typhoid fever in the city of Albany. The average death rate per hundred thousand of this disease for the city of Albany, was 85 for 9 years ending with 1898. During the 4 months in which the filters had been in operation, 7 deaths had been reported, and for the corresponding months of 9 years ending with 1898, the average number was 24.

Mr. George C. Whipple, in discussing the value of pure water, gives the following interesting table, comparing the death rate before and after filtration of the water supply of Albany:

ALBANY.

EFFECT OF FILTRATION ON DEATH-RATES AT ALBANY, N. Y., AND A COMPARISON WITH TROY, N. Y., WHERE THE WATER WAS NOT FILTERED.

Condition	DEATH RATES FOR 100,000			
	1894-98, before Filtration at Albany	1900-04, after Filtration at Albany	Difference	Per cent. Reduction of Death-Rates
Typhoid fever	104	26	78	75
Diarrheal diseases	125	53	72	57
Children under 5 years	606	309	297	49
Total deaths	2,264	1,868	378	17
TROY.				
Typhoid fever	57	57	0	0
Diarrheal diseases	116	102	14	12
Children under 5 years	531	435	96	18
Total deaths	2,157	2,028	129	6

He calls attention to the very interesting fact which has been observed before, that the reduction of the typhoid fever death rate following the substitution of pure water for a contaminated water is often accompanied by a drop in the death-rate from other diseases. The above table shows the reduction from general diarrhoeal disease, and the deaths of children under 5 years of age were much greater than in the case of typhoid fever.

t the reduction of infant mortality and deaths from diar- liseases was not due to other conditions seems probable from t that in the neighboring city of Troy, where the water was not changed, there was no such diminution during the eriod."

following table by the same author is a summary of the l fever death rates in different cities and towns of the r which used ground waters or filtrated waters:

STATE	Number of Cities and Towns Averaged	Number of Years Averaged	Average Typhoid Fever Death-rate per 100,000
....	2	5	6.4
ısetts....................	23	5	15.8
cut.......................	4	5	9.5
k.........................	13	5	24.7
ey........................	10	1	20.5
ania......................	5	1	31.8
....	22	5	32.4

subject of water supply for rural communities will become nd more important as the years go by. Dr. H. B. Stone and Moat, in making a study of the ground waters of Vermont, ention to the contamination of the ground waters because of ıg use of wells and buildings. "The Vermont farm and ıuse are old; generation after generation has in turn added ecta to the soil which has gradually been permeated to a rable distance so that we find the unmistakable marks of , recent or remote, in many of these old wells which are red by the users to be as unimpeachable as when they were nced good by their ancestors." They find that the total ate of typhoid fever in that State is 31.1. Of the urban tion, the rate is 27.8, while among the rural population it 31.7, per 100,000. It is always safer, in a densely populated , to use filtered water in preference to water from a stream ısses through a country where there are some chances of pollution. It is safer to allow the water to be stored and ıs has been well shown by Dr. Sedgwick, the organisms ninish. "Conversely, if a running water such as we have in can be converted into a quiet water,—as in a reservoir,— ch purification as we have discovered in Burlington may re- This is, indeed, what takes place, fortunately, with water l from polluted watersheds and stored in huge reservoirs,— ınd often adequate purification may be established by pro- quiescence, or storage. There is every reason to believe

that the principles involved in the purification which goes on in Burlington are typical in whole or in part of many other similar cases. Some bacteria perish almost immediately in the cold water of the lake; some settle to the bottom and perish there; some are killed by light as they float on the surface; some are devoured by predatory infusoria; the more hardy survive, perhaps, but do not multiply because of lack of food and other unfavoring conditions, and so are simply scattered by dilution; until finally only those remain which can permanently thrive in the now relatively pure water; and these are apparently mostly harmless."

It has been shown that a rapidly flowing stream is not so injurious to the bacteria as a stored body of water. It may be of interest in this connection also to call attention to the elimination of typhoid fever and intestinal bacteria in water coming from the Chicago Drainage Canal. In a report made by Drs. Jordan, Russell and Zeit it was shown that the typhoid organisms soon lost their vitality. "It may be concluded that the vast majority of the typhoid bacilli introduced into the sewage of the Chicago Drainage Canal, under the conditions which prevailed during the conduct of this experiment, disappear within two days after their introduction, and that while it may be true that individual cells endowed with special powers of resistance maintain their vitality for a longer period, the outcome of this experiment shows that such an assumption finds little warrant. Furthermore, assuming that such survival of typhoid bacilli with rare powers of resistance did sometimes occur, there is some ground for supposing that such adaptation to a saprophytic mode of life might be associated with a lowered virulence. The facts instanced by Hankin, and by Remlinger and Schneider, regarding the occasional presence of typhoid bacilli in natural waters apparently possessed of slight virulence, or even wholly innocuous, are sufficient to demand careful consideration of this possibility."

Since then, H. L. Russell and C. A. Fuller carried on investigations of the longevity of the typhoid fever bacillus of natural waters and they arrived at the very important conclusion that these typhoid organisms lived somewhat longer.

"Comparing these two types of surface waters, one from an inland lake, of moderate dimensions, the other from a very much larger water reservoir, it appears that the results of these two sets of experiments are not greatly different. In Professor Zeit's work, the average period of longevity was about seven days, while in our studies it has ranged from 8 to 10 days. Still, by far the most

of the typhoid organisms disappear before the end of a week. It is, however, necessary to set the limit at complete disappearance, although it has been generally noticed that there are often a few seemingly more resistant individual germs that persist for an appreciably longer time than the average."

The low death rate from typhoid fever is well shown where filtered water is used as in the case of the city of Amsterdam, Holland, with a population of a half million, which has a death rate varying from 8½ to 19 per 100,000. Taking the city of Lawrence, Mass., which has had a particularly high death rate of typhoid fever, we find that the death rate varied from 48 to 123 per hundred thousand. Lawrence used unfiltered water. Taking a few illustrations of the interior of the country, we find that the death rate of typhoid fever in some cases is unusually high, as in the city of Denver, where the number has fluctuated from 30 to 217 per hundred thousand population. The cities taking their supply from the Great Lakes are not exempt from danger; this is shown in the death rate from typhoid fever; in Chicago, prior to the installation of the present drainage canal, the death rate fluctuated from 31 to 160 per hundred thousand. It may be of interest to note in this connection that the city of Des Moines has an unusually low death rate from typhoid fever.

Mr. A. M. Bleile, who made a study of the sources of public water supplies of Ohio, makes this statement with reference to the Scioto River, which furnishes the city of Columbus with water: "There is not a progressive increase in the number of bacteria straight down stream. In other words, it is apparent that the large number of bacteria which gain access to the river are lost in some way, that is, that the water purifies itself as it is carried on through the stream bed. This can best be seen if we compare the figures shown by a station below town with the figures obtained at the station below, above the next town. Just how much purification takes place in a running stream and how this purification or destruction of bacteria is effected, are moot questions. Several causes are here invoked. It is known that exposure to sunlight will kill off many forms, and it is further known that aeration, while it will at first increase the number of bacteria, will eventually cause the destruction of a large number of them. Then, sedimentation may be a factor of some moment, though that this should be very great in the rivers here in consideration, does not seem probable. Then it is to be borne in mind that our bacteria must be of a low specific gravity, not much different from that of water, and that they there-

fore would not tend to settle rapidly. Further, many forms are endowed to a high degree with the power of motility, and there is no reason to assume that they would seek the bottom of a stream rather than the higher portions of the water. It is true that the sediment of a river may be found higher in bacteria than the water, but this would follow from the fact that this sediment contains large quantities of organic matter, food for the bacteria, and that they would increase enormously in this habitat. This purification goes on to a marked extent, even in the course of a few miles, as witness, for example, the numbers for August below Columbus, 195,100, and at Shadeville at the same time, seven miles below, where the number drops to 885."

Burrill, Jordan, Zeit, Long, and others concluded that the discharge of the Chicago sewage into the valley of the Illinois had no effect whatever upon the Illinois River at its mouth beyond increasing the chlorine and other mineral constituents. They found that between Chicago and Peoria, that some of the streams flowing into the Illinois, had as many organisms as the Illinois River above Peoria which had been richly charged with sewage organisms from Chicago drainage canal.

It was my privilege, last Summer, to investigate, along with Prof. Bissell of Ames, John W. Alvord of Chicago, Prof. W. T. Sedgwick of Boston, Mr. J. R. Freeman of Providence, Rhode Island, Prof. A. C. Abbott of Philadelphia, Prof C. Harrington of Cambridge, and Prof W. J. Roberts of Pullman, Washington, the supposed pollution that would follow the construction, maintenance and operation of the Chicago, Milwaukee & St. Paul Railway, through a portion of the Cedar River watershed from which the city of Seattle obtains its water supply. The case is of particular interest because the question had not been raised prior as to the possibility of pollution from a railroad by merely passing through a watershed and alongside a stream supplying a large city with water. The railroad was particularly anxious to obtain a right of way to the city of Seattle, which owned a portion of the territory of the watershed, in order to get an easy grade into the city. The writer had been in correspondence with the president of the road in Washington, concerning the danger of such pollution, and he gave it as his opinion that if the stream was properly safeguarded, during construction and maintenance, pollution would not occur. The city council finally passed an ordinance granting a strip of land 100 feet wide to keep within certain distances from the river bed, that the bridges should be solid-decked structures, and approaches to them and trestle should be so constructed and maintained as to prevent anything

lropping from the engines and cars into the river; that all necessary precaution should be taken during the construction of the railway. It was provided further that the living quarters of any and all employees engaged in the care and maintenance of the road should be located at such distances from the river as directed by the city, and that no stations should be established or maintained between the city intake and easterly terminus. The city was further authorized to employ the services of an inspector during the process of construction. The ordinance was duly signed by the mayor. The King's County Medical Society protested, stating that the city water supply in spite of all precautions would become contaminated. Somewhat later the State Board of Health also took up the matter and protested. It was thought best to have a thorough examination made of the water supply to decide this question. The ordinance on suggestion of some of the experts was amended so as to provide for filtration areas and for the appointment of a sanitary engineer subject to the approval of the State Board of Health. Said engineer to have full control in all matters pertaining to sanitation and power to prescribe sanitary regulations for man and animals; to employ one or more inspectors who shall enforce such regulations and rules, and shall have special police powers. These rules shall have the approval of the State Board of Health. He shall employ one or more competent physicians who shall examine and report to the city and State Board of Health upon all cases of illness and shall cause the immediate removal from the watershed any afflicted with a communicable disease. The salaries and compensations of all persons so employed shall be paid by the grantee, successors, or assignees. The ordinance further provides that while trains are being operated over the right of way granted by the city of Seattle, all closets shall be locked or provided with receptacles to prevent human waste from falling upon the road bed, whenever so required by the State Board of Health.

In order to properly discuss this matter, it will be necessary to look at the conditions found elsewhere in the country. It is almost impossible to find a watershed in the more settled portions of the United States but what is traversed by railways, and in many, these railroads follow the streams for miles, in many instances a few feet from the edge of the water, but so far as I know, no complaint has been made that railroads pollute the water. A notable illustration is the city of Altoona, Pennsylvania; at this point the Pennsylvania Railroad has four extensive shops. There are four tracks, and thousands of passengers are carried over these tracks every day, besides an enormous amount of freight. The

water supply for the city of Altoona is from surface streams and reaches the city by gravity. The water is collected into reservoirs, and from these the water is distributed to the city. The elimination of most organisms is brought about through the action of sedimentation. Taking the death rate for typhoid fever from 1898 to 1901, we find that it varies from 9 to 31 per hundred thousand, and for most years it was below 20. The typhoid fever death rate for a few cities is as follows. These figures were at the rate of per hundred thousand. Some of these cities are traversed by railways. The death rate for Boston is 26; New Orleans, 49; Columbus, Ohio, 51; New York, 19; Detroit, 18; Denver, 30; Hartford, Conn., 58; Milwaukee, 18; Chicago, 31; Pittsburg, 122; San Francisco, 31; St. Louis, 31; Washington, D. C., 66; Wilmington, Del., 38; Louisville, 60; Philadelphia, 51; Minneapolis, 42.

Mr. Alvord has given the following table showing the population in 1900, source of the water supply, and approximate mileage of railroads, and the number of stations:

City	Population in 1900	Source	Approximate Mileage of Railroad and No. of Stations
New York	3,350,000	Croton River	45 miles railroad, 18 stations
Boston	560,000	Nashua River, Sudbury and Cochituate	34 miles
Baltimore	508,000	Gunpowder River	38 miles parallel, 41 stations on map
San Francisco	342,000	Lake Merced, mountain stream	None
Providence, R. I.	175,000	Pawtucket River	10 miles, 10 stations
Kansas City	163,700	Missouri River	Over 300 miles in immediate vicinity
St. Paul	163,000	Small lakes	No railroad
Rochester, N. Y.	162,000	Hemlock lake	No railroad, summer resort around lake
Denver, Col.	133,850	South Platte	75 miles, 14 stations
Worcester, Mass	118,400	Lynde Brook	No railroad
New Haven	108,000	Mill River	35 miles, 10 stations
Fall River	104,800	Watuppa Lake	5 miles, 3 stations
Omaha, Neb.	140,000	Missouri River	210 miles below Sioux City, 12 stations
Scranton, Pa.	102,000	Roaring Brook, Oak River	10 miles
Cambridge, Mass.	92,000	Stony Brook	5 miles
Grand Rapids	87,500	Grand River	260 miles, 70 stations
Richmond	85,000	James River	150 miles parallel, 92 stations
Hartford, Conn.	80,000	(Brooks)	15 miles, 4 stations
Trenton, N. J.	75,000	Delaware River	100 miles parallel
Waterbury	45,800	(Ponds)	No railroad
Mobile	38,400	Clear Creek	No railroad

However, that typhoid fever can be occasionally spread through carelessness on the part of railroads has been made evident in the report of typhoid fever in Butler, Pennsylvania. The city of Butler, with a population of 18,000, is situated in Butler County on a little creek 39 miles from Pittsburg, with an average elevation of 1,050 feet above sea level. The country is sparsely settled; several railroads enter the city. The water is derived from private wells, the Butler Mutual Water Association, and the Butler Water Company. A mechanical filter plant was established in 1902. The filters contain six inches of gravel and three and a half feet of natural sand. During a part of the epidemic, this filter plant was not in operation. It was shown on investigation that there were several cases of typhoid fever in families living near the reservoirs on Thorn Run and Boydstown. Bacteriological examinations revealed that the number of organisms was not large, generally below 1,000, but in a few instances from 14 to 50,000. In a few cases, the colon bacillus was found. The watershed comprises 28,217 acres; it is sparsely settled at the rate of about 24 persons per square mile. The place is broken and hilly, and the run-off of water very rapid. Near the head waters is located a little village called Greece City. An investigation of the entire watershed showed that not only had typhoid fever existed at various points within its boundary, but in 1902 the unusual number of 14 cases had occurred, and in 1903, 17 cases coincidently in the months of September and October. Three of these died. In 1903, the cases were divided among eight families; two of the cases occurred within 1,500 feet of the intake at the pumping station. The probable source of infection in the cases in close proximity to the pumping station was a well within 200 feet of the house, and partially underlying the tracks of one of the railroads. The source of infection in the four cases existing in September in close proximity to the Thorn Run reservoir originated in the person of a visitor from a distant section of the State. It was found, further, that the train crews and men to the number of 70, working on the railroad made use of the numerous privies found in close proximity to the stream and that this may have helped to spread the disease.

Prof. Roberts, in speaking of the drainage area of Seattle, says: "Cedar River, from which Seattle derives her water supply, has a tributary drainage area at the intake dam of 150 square miles; at the power dam at Cedar Lake 75 square miles. With an annual rainfall, over the entire area, approximately 100 inches. The area

of the lake is about two square miles. From the power house, abou three miles below the lake, to the intake, ten miles down stream, th river falls 35 to 40 feet per mile. Its principal tributary is Taylo Creek, flowing into the river near Barneston, and contributin about 20 per cent of the entire flow at that point. Other small creeks and large springs swell the volume flowing during the lo water season from 30 cubic feet per second at the power house 160 cubic feet per second at the intake—a volume sufficient to supp 1,000,000 people if taken direct from the running stream, and su ficient for three or four million people if the total capacity of t water shed could be stored. Its purity at the present time is almo unquestioned. The entire water shed was heavily timbered un certain portions were logged off and burned over. The city Seattle has acquired about 11,000 acres contiguous to the river a lake shores in order to the better protect her interests in this sour of supply.

"The major portion of the valley from power house to intake is glacial drift: boulders, gravel and sand, interspersed with be of clay and strata of cement gravel and hard-pan. Occasional dik of trap and porphyry have intruded, and in the lower part of t valley broken blocks of basalt lie en masse."

Originally, the region was heavily timbered, but from a portion the water shed, the timber has been removed. Logging roads ha been constructed through the region. In regard to the nature the material from which the railroad passes, the following repo was made by Professors Abbott, Sedgwick and Harrington:

"It appears that along much of the proposed location, gravel a sand are not to be found. The forest floor appears to be reasonab thick, but at most points it consists almost wholly of combusti matter; and where fires have occurred the soil is shown to be chie loose rock, with neither sand nor gravel, and consequently n porous and suitable for effective filtration. At some points alo the route clay and silt deposits are evident; but these materials a not suitable filtering media, for they do not permit percolation. view of these facts, special provision will be necessary for prop disposal of such waste matters as may find their way to the surfa of the ground within and near the limits of the right-of-way duri construction and operation of the road; for without such provisio the said wastes would inevitably be washed into the river in tim of heavy rainfall, and, in the event of their containing pathoge organisms, might lead to disastrous outbreaks of infective diseas The fact is, however, that the character of the water can be ac

quately safeguarded by the adoption of methods which will be described in detail further on."

On the same point, Mr. Henry Alvord makes this statement:

"The watershed of the Cedar River above the intake appears to be one of the most extensive areas of porous soil utilized for natural filtration of a public water supply which it has ever been my fortune to observe. The glacial drift of which it is composed consists of coarse and fine gravels intermingled to a depth of some hundreds of feet. We looked in vain for traces of clays or finer soils. The surface mould is thin for the most part, and the lėvel of the soil water on the benches and plateaus back from the river is evidently at a great distance below the surface, as indicated by the location of springs and the depth of the eroded streams. There is little or no surface run-off of the rainfall. Numerous potholes exist, depressions without visible outlet, and there was scarcely observed a dry run of any kind, or rivulet, save those of running streams, few in number, which were marked upon our map.

The unusual porosity of the soil may be best illustrated by the statement that in passing over the located line of the railway, eleven miles along Cedar River, no run or rivulet or surface indication of any kind was observed leading into the stream which would indicate that the rainfall passed over the surface of the ground. We also observed that in passing over the Northern Pacific Railway, which crosses the watershed from north to south, no pains was taken by that company to ditch its tracks, to provide small culverts, or even, in the case of very considerable depressions, to arrange for the passage of water from one side of its embankment to the other. The soil, therefore, of this valley is a porous one, receiving the copious rainfall of this region and largely absorbing it, and by slow percolation filtering it to an unusual degree, thus creating the clear streams and exceptionally pure water."

Prof. G. W. Bissell says:

"The Cedar river watershed is formed in a vast deposit of glacial drift, from which the river and its tributaries have eroded channels in general to the solid rock. In the case of the Cedar river intake, there have been probably three different shore lines in the past, which have existed long enough to form benches, or steps, in the slopes of the river valley sides, this being especially noticeable in the vicinity of Barneston. Except where clearing for railroads, trails, logging purposes or by fire has been effected, the whole watershed is heavily timbered. Most of the surface of the watershed is very sloping, and much of it is very steep; the benches and

plateaus are nearly level, or slope back from the watercourses. There are numerous pockets, or sink holes, from which drainage is impossible.

The subsoil is almost entirely a coarse gravel, the interstices of which are filled with finer material. The thickness of this gravel deposit of glacial drift is evidently, in most cases, several hundred feet. Very little clay was found. There are some boulders and outcropping rock. Overlying the gravel in the timber areas is a surface covering a few inches to two feet in thickness of porous loam and humus, and the space between trees is almost filled by impenetrable undergrowth. The gravel which underlies this region is the best possible natural filter for surface impurities, and is of such thickness and extent as to preclude the access of surface pollution to the watercourses by percolation. The percolation, of course, of water takes place, but the material is of such a nature that thorough filtration is effected before the water has sunk very far into the ground.

Nature has made excellent provision for rendering innocuous objectionable material deposited on the natural ground surface of the watershed. In the case of direct pollution of the stream by deposit of objectionable or dangerous matter therein, nature's resources for self-purification are somewhat restricted, and reliance must be principally on the effect of time and aeration of the contaminated water from the point of such contamination to its point of consumption. In some cases the water is cold enough to be a factor, by reason of such low temperature, in self-purification. Experience shows that this reliance is not always warranted, and sanitarians have placed a ban on direct pollution of streams which are the sources of supply of potable water."

From the results of the investigation of the watershed which it was my privilege to examine, we found a considerable bed of clay on one of the tributaries of the Cedar River, on what is known as Taylor Creek; here a number of large springs issued and entered Taylor Creek where the present Miller logging camps are located. Another series of large springs emptied into the Cedar River near the present intake of the Seattle water supply. I need only say in this connection that the water coming from these springs contained an unusually small number of organisms; it was bright and sparkling. Bacteriological analyses were made of water from various sources from the Cedar River and its tributaries, with the following results:

Location	Date of Pl'g	Date of Ct'g	Gelatin Non-Liquefying	Gelatin Liquefying	Agar	Litmus Lactose Agar	Total	Temp. of Water
Cedar River, Barneston, below N. P. bridge	7-18	7-21	10	10	0	0	20	61
		7-21	10	....	....	....	....	No
		7-22	10	10	10	10	....	pollution
		7-22	10	0	10	10	....	
		7-23	10	0	....	10	....	
		7-23	10	30	10	10	40	
Cedar River, Barneston, above N. P. R. R. bridge......	7-18	7-21	10	10	0	10	20	61
		7-21	10	30	0	10	40	No
		7-22	20	30	10	10	50	pollution
		7-22	0	10	10	10	10	
		7 24	10	30	10	10	40	
		7-23	10	10	10	10	20	
Taylor Creek at mouth.........	7-18	7-21	0	20	0	0	20	61
		7-21	0	10	0	0	10	No
		7-22	0	10	20	30	30	pollution
		7-22	40	10	10	40	50	detected to
		7-23	....	....	10	10	10	date
		7-23	....	....	10	40	40	
Barneston, barrel on top N. P. R. R. bridge......	7-18	7-21	20	40	0	0	60	75
		7-21	180	50	0	0	230	Pollution.
		7-22	180	50	40	0	230	Stagnant
		7-22	50	30	20	40	80	water,
		7-20	....	....	40	40	40	many
		7-23	....	....	20	....	20	liquefiers
Cedar River, above dam, lower end Cedar Lake......	7-19	7-21	0	0	0	0	0	68
		7-21	0	0	0	0	0	
		7-22	0	....	0	10	10	
		7-22	0	0	0	0	0	
		7-24	0	50	40	50	50	
		7-24	0	40	50	40	40	
Taylor Creek, Miller Camp No. 5, sewage near creek.........	7-20	7-21	0	0	1,000	2,000	2,000	Anaerobes
		7-21	1,000	0	13,000	1,000	13,000	and
		7-22	2,000	....	4,000	6,000	6,000	pollution
		7-22	5,000	....	5,000	13,000	13,000	
		7-23	5,000	....	14,000	20,000	20,000	
		7-23	5,000	5,000	6,000	6,000	6,000	
		7-24	5,000	5,000	20,000	60,000	60,000	
		7-24	20,000	....	....	50,000	20,000	
S. W. shore of Cedar Lake....	7-19	7-22	0	0	0	0	....	68
		7-22	0	0	10	0	....	No
		7-23	0	0	0	10	....	pollution
		7-23	0	0	10	0	....	

Location	Date of Pl'g	Date of Ct'g	Gelatin Non-Lique-fying	Gelatin Lique-fying	Agar	Litmus Lactose Agar	Total	Temp. of Water
Taylor Creek, below Miller Camp No. 5..........	7-20	7-21	0	....	30	20	30	55
		7-21	....	....	0	10	10	Anaerobe
		7-22	40	2	40	200	200	
		7-22	20	....	20	40	40	
		7-23	140	....	40	20	140	
		7-23	....	....	20	200	200	
		7-24	....	....	600	....	....	
		7-24	....	....	400	....	400	
Swamp near outlet of Cedar Lake	7-19	7-21	20	0	....	....	....	69
		7-21	0	0	....	....	....	One mould
		7-22	20	0	20	20	20	
		7-22	0	0	40	10	40	
		7-23	20	0	20	50	50	
		7-23	20	0	40	20	40	
		7-24	20	20	40	50	50	
		7-24	....	....	10	30	30	
Barneston water supply from tap near store, Taylor Creek, through pipe ¾ mile	7-19	7-22	....	....	0	10	10	
		7-22	....	....	10	10	10	
		7-23	....	....	0	10	10	
		7-23	....	....	10	20	20	
Cedar River below power house..........	7-19	7-22	0	0	0	0	0	61
		7-22	0	0	0	0	0	No
		7-23	0	0	0	10	10	pollution
		7-23	0	0	10	0	0	
One mile from dam, S. W. shore..........	7-19	7-22	0	0	10	10	10	68
		7-23	0	0	10	10	10	No
		7-23	0	0	0	10	10	pollution
		7-22	0	0	10	10	10	
Mouth of Rex River, 200 feet from shore....	7-19	7-22	0	0	0	0	0	68
		7-22	0	0	0	0	0	No
		7-23	0	0	0	0	0	pollution
		7-23	0	0	0	0	0	
Upper end of Cedar Lake near Cedar River....	7-19	7-32	0	0	0	0	0	68
		7-22	0	0	0	0	0	No
		7-23	0	0	0	0	0	pollution
		7-23	0	0	0	0	0	
Cedar River, half way between power house and Barneston.	7-19	7-22	....	....	0	0	....	64
		7-22	....	....	....	....	....	No
		7-23	0	0	0	0	0	pollution
		7-23	0	0	10	10	10	

The results obtained and tabulated above show considerable pollution of Taylor Creek water near the Miller Logging Camp. After returning home, further cultures were made; the presence of gas was noted. The number of organisms had increased somewhat.

Location	Date of Pl'g	Date of C'tg	Gelatin		Agar	Litmus Lactose Agar	Acid	Gas
			Non-Liquefying	Liquefying				
Cedar River Barneston, below N. P. bridge....	8-7	8-9	....	....	....	55,000	......	32H+
		8-9	....	....	....	30,000	......	$42CO_2$
Cedar River Barneston, above N.P.R.R. bridge	8-7	8-9	....	....	....	8,000	0	0
		8-9	....	....	....	40,000	0	0
Barneston, barrel on top N P. R. R. bridge.......	8-7	8-9	....	....	....	48,000	......	32H+
		8-9	....	....	....	36,000	......	42CO
Above Barneston..	8-7	8-9	....	....	....	8,000	......	0
		8-9	....	....	....	40,000	......	0
Cedar River, above dam, lower end Cedar Lake.....	8-7	8-9	30	0	....	40	......	20H+
		8-9	60	20	....	30	......	$19CO_2$
Taylor Creek, Miller Camp No. 5, sewage near creek	8-7	8-9	....	....	....	180,000	0	68H+
		8-9	....	....	....	....	......	$62CO_2$
S. W. shore of Cedar Lake........	8-7	8-9	....	....	30	....	......	0
		8-9	....	....	40	....	......	0
One mile out....	8-7	8-9	....	....	10	....	......	0
		8-9	....	....	20	....	......	0
Cedar River below power house....	8-7	8-9	10,000	0	10,000	20,000	......	30H+
		8-9	10,000	....	10,000	10,000	......	$14CO_2$+
One mile from dam, S. W. shore.....	8-7	8 9	....	....	....	12,000	......	20H+
		8-9	....	....	....	9,000	......	$8CO_2$+
Mouth of Rex River, 200 feet from shore...........	8-7	8-9	....	....	60,000	0	......	0
		8-9	....	....	48,000	0	......	0
Upper end of Cedar Lake near Cedar River...........	8-7	8-9	....	....	....	168,000	......	48H+
		8-9	....	....	....	48,000	......	....
Cedar River, half way between power house and Barneston.......	8-7	8-9	....	....	....	18,000	0	0
		8-9	....	....	....	8,000	......	0

A considerable number of the samples of water contain gas producing organisms, but in no instance did we find the colon bacillus, excepting in the water from the Taylor Creek camps. The small number of organisms in the water from various sources, excepting the logging camps, when plated soon after collecting, indicates a good supply of water and little organic matter. The temperature of the water at different points is such that organisms do not multiply rapidly. The temperature of the water at different points is indicated in the following table:

Locality	Time	Temperature of water	Temperature of air
Swamp south end of lake, surface	4:30 P. M.	69	..
1 foot from surface	4:30 P. M.	68	..
Cedar Lake, water near shore	4:30 P. M.	69	..
Power House, Cedar River	7:00 P. M.	66	..
Mouth Cedar River, head of lake	3:00 P. M.	70	..
Swamp, Cedar River, upper end of lake	3:30 P. M.	69	..
Cedar River dam	1:30 P. M.	68	72
Cedar Lake, ½ mile from dam	1:40 P. M.	69	72
Cedar Lake, 1 mile from dam	2:00 P. M.	68	72
Cedar Lake, 2 miles from dam	2:30 P. M.	68	72
Cedar Lake, southwest shore rocky promontory	3:00 P. M.	70	72
Cedar River, half way to power house	10:00 A. M.	61	66
Cedar River water, 2½ miles from power house to Barneston	8:00 P. M.	64	..
Taylor Creek, 1 mile from Barneston	9:00 A. M.	50	68
Taylor Creek, ½ mile up stream	10:00 A. M.	55	80
Taylor Creek	11:30 A. M.	42	84
Spring Water	11:45 A. M.	43	84

There seems to have been a difference of opinion with reference to the nature of the soil as a filter medium. The writer, in his report on this subject, made the following statement:

The water dropping on the humus, percolates through the humus and a carpet of many small plants and humble mosses, then into a stratum of sand and gravel mixed in such way as to make a good filter.

Professors Sedgwick, Harrington, and Abbott quoted elsewhere in this paper, made a statement that it was not an ideal filter. It is true as I have said, that at two points there are beds of clay, but nowhere along the proposed right of way. To test the efficiency of filtration, samples of soil were collected at different points and on my return home the soil was placed in galvanized iron cylinder 18 inches long. Ordinary deep well water having an average of 4 bacteria per cc. was allowed to percolate through the soil and th

number of organisms per cc. was determined. Then College sewage was allowed to percolate through these same cylinders filled with earth. The results obtained were as follows:

All plates were plated on the 15th of August and counted on the 17th. The College sewage had 540,000 bacteria per cc. The College water supply, 40 bacteria per cc. The number of organisms found in different media in effluent from different soil samples were as follows: Sample taken near river, 1/4 mile below Power House, Litmus lactose agar, 100, 500, and 300 bacteria per cc. Below Barneston, about half way to city intake, where the railroad will be quite close to the stream, the number of organisms per cc. was as follows: 140, 300, and 1,350. Sand and gravel half way between Power House and Barneston: Litmus lactose agar, 350, 400, and 300 bacteria per cc. This although not a crucial test because the experiment should have been conducted over a longer period, seems to indicate efficient filtration of sewage organisms. The water coming through the soil was clear, after the liquid was allowed to percolate through for an hour or more. The writer is indebted for the mechanical analysis of the soils to Mr. E. B. Watson of the Soils Department of Iowa State College. This analysis shows considerable gravel and sand but a small amount of clay. The point below Barneston was 50 feet from the river; sample No. III was 20 feet from the river.

REPORT OF MECHANICAL ANALYSIS OF SOIL.

Soil	Coarse gravel greater than 2 m. m. %	Analysis of "Fine Earth," Finer Than 2 M. M.								
		Fine gravel 2-1 m. m. %	Coarse sand 1-.5 m. m. %	Medium ssnd .5-.25 m. m. %	Fine sand .25-.1 m. m.	Very fine sand .1-.05 m. m. %	Total sand 2-.05 m. m. %	Silt .05-.005 m. m. %	Clay .005-m. m. %	Total %
I. One half way between Barneston and power-house..............	53.1	14.03	16.58	8.50	14.24	8.50	61.85	29.55	7.86	99.26
II. Below Barneston	5.9	1.42	4.10	4.70	32.36	21.21	63.81	30.13	6.07	*
III. Just below power house	61.4	17.40	12.79	5.66	22.01	11.74	69.60	23.06	7.34	†

*100.01. †100.00.

Mr. E. B. Watson calls my attention to the results of some work carried on by the Bureau of Soils[1] with reference to the absorption of organic matter.

1. Bul. Bureau of Soils, 23:46.

Attempts have been made to improve a lawn by applications of manure. It was noticed that the manure quickly disappeared and did not have the effect on the soil that was desired. There was no marked change in color even after two applications of twenty-five tons of manure per acre. Experiments indicate that organic matter added to the lawn oxidizes directly, the amount of CO_2 given off being equivalent to the amount of oxygen absorbed by the soil in closed vessels. The organic matter added to the lawn in its present condition decomposes very quickly with little, if any, formation of humus. In this respect the lawn, which is a very dry natured soil, seems to act similarly to a dry earth closet.

The mechanical analysis of the Tacoma lawn soil as published in the bulletin referred to is as follows:

Conventional Names	Sample I	Sample II
	Per cent	Per cent
Fine gravel	4.1	2.5
Coarse sand	28.4	32.5
Medium sand	10.8	12.1
Fine sand	8.2	8.0
Very fine sand	2.7	2.3
Silt	29.2	26.9
Clay	16.5	15.5

The Washington soils differ from this in having only half the amount of clay and considerably more fine and very fine sand. The percentages of silt are the same. In general the soils are somewhat similar.

ɛw years ago, the writer investigated the water supply found ious watersheds traversed by railroads. The summary of ı with regard to the presence or absence of the colon bacillus, ɛ of interest in this connection:

Stream	Locality	Presence or Absence of B. coli communis	Railroad Paralleling Stream
eek..........	North of Denver......	Absent.	Colorado Southern
s............	Pueblo, Colo.........	Absent.......	D. & R. G., Santa Fe; C. F. I.
s............	Salida, Colo..........	Absent...... ..	Denver & Rio Grande
s............	Shirley, Colo.........	Absent.	Denver & Rio Grande
ributary of sas..........	Marshall Pass, Colo ..	Absent.	Denver & Rio Grande
n............	Grand Junction, Colo.	Absent.	Denver & Rio Grande
.. ..	Grand Junction, Colo.	Absent........	Denver & Rio Grande
iver.........	American Falls, Idaho	Absent........	O. R. & N.
latte.........	North Platte, Neb....	Absent........	Union Pacific
iver.........	Waterloo, Iowa	Present sewage from Cedar Falls.......	C., R. I. & P.
ow Creek, na.......	Butte, Mont..........	Absent........	Northern Pacific
one, Mont...	Livingston...........	Absent........	Northern Pacific
one, Mont...	Billings..............	Absent........	Northern Pacific
one, Mont...	Glendive.......	Absent........	Northern Pacific
River, Wash.	Green River Hot Springs....	Absent........	Northern Pacific
nes, Iowa....	Boone...	Absent........	C. & N. W.
ver.	Des Moines...........	Absent........	C., M. & St. P.
ɛtte	Salem................	Present sewage empties into river from Salem......	S. P.

Stream	Date of collection of water	Number of bacteria per c. c.	Bacillus fluorescens	Gas	Remarks
Ditch from Clear Creek, Golden, Colo.	July 20	7700 9400	800 1400	+ +	Water mudd
Average	....	8050	1100		
Arkansas, Pueblo, Colo	July 22	9800 13600	2800 1400	+ +	Water mudd
Average	....	11700	2100		
Arkansas, Salida	July 23	28000 45000	10000 12000	+ +	Water mudd
Average	....	36500	11000		
Arkansas, Shirley, Colo	July 23	7200 8000	1000 1600	0 0	Slightly turb
Average	....	7600	1300		
Tributary of Arkansas, Marshall Pass, Colo	July 23	600 500	50 100	0 0	Clear
Average	....	550	75		
Tributary of Arkansas, Marshall Pass, Colo	July 23	120 20	0 0	0 0	Clear
Average	....	70	0		
Gunnison, Grand Junction, Colo	July 24	1750 1820	20 50	0 0	Clear
Average	....	1785	35		
Snake River, American Falls, Idaho	July 25	350 250	0 0	0 0	Clear
Average	....	300	0		
Large Spring at edge of Snake River	July 25	50 80	0 0	0 0	Clear
Average	....	65	0		
Green River, Washington	Aug. 9	32000 28000	3200 2800	+ +	Turbid
Average	....	30000	3000		
Silver Bow, Butte, Mont	July 20	20000 12000	1400 3500	0 0	Water mud
Average	....	16000	2450		

Stream	Date of collection oi water	Number of bacteria per c. c.	Bacillus fluores. cens	Gas	Remarks
Yellowstone, Livingston, Mont........	Aug. 17	500	......	0	Slightly turbid
		350	......	0	
Average..........	....	425	......		
Yellowstone river, Billings, Mont......	July 14	4200	......	0	Water cloudy
		2800	......	0	
		2400	......	0	
		2000	......	0	
		60	......	0	
		250	......	0	
Average..........	....	1951	......		
Glendive, Yellowstone River..........	....	14000	......	0	Water muddy
		40	......	0	
		3200	......	0	
		1050	......	0	
Average......	....	4572	......		

The above table shows the number of organisms found in the different streams. I may say that in connection with the test for colon bacillus, the writer used from one to ten cubic centimeters of water. It may be said in this connection, however, that the quantity of water used was perhaps too small. It may be added further in this connection, with reference to the Cedar River water, that a large amount of debris, such as logs, shingles and lumber, in the water will somewhat help to remove the organisms that are found in the stream.

The cases cited above indicate that railroads paralleling streams do not contaminate the same from the dejecta or the passage of tramps up and down the right of way of the railroad. The presence or absence of *B. coli-communis* is given, because this organism indicates fecal contamination.

There was no doubt in my mind through the entire region of the Cedar River to be traversed by the railroad, that there will not be any danger from sewage pollution, or contamination, provided proper precautions will be observed. The opinions expressed by different investigators concerning this problem, are best stated in their own words.

Professors Abbott, Sedgwick, and Harrington state:

"It appears that along much of the proposed location, gravel and sand are not to be found. The forest floor appears to be

reasonably thick, but at most points it consists almost wholly of combustible matter; and where fires have occurred the soil is shown to be chiefly loose rock, with neither sand nor gravel, and consequently not porous and suitable for effective filtration. At some points along the route clay and silt deposits are evident; but these materials are not suitable filtering media, for they do not permit percolation. In view of these facts, special provision will be necessary for proper disposal of such waste matters as may find their way to the surface of the ground within and near the limits of the right of way during construction and operation of the road; for without such provisions, the said wastes would inevitably be washed into the river in times of heavy rainfall, and, in the event of their containing pathogenic organisms, might lead to disastrous outbreaks of infective disease. The fact is, however, that the character of the water can be adequately safeguarded by the adoption of methods which will be described in detail farther on.

"The safeguarding of the water supply during the construction of the proposed road is by no means a simple matter, for construction involves the introduction of large numbers of men into the watershed, whose wastes must be prevented from reaching the river. It will be necessary to establish camps at various places, and these camps must be provided with water, must be drained, must be provided with bathing and laundry facilities and latrines, and in all respects must be under constant competent sanitary inspection and control far more stringent than, under ordinary conditions, is necessary. It is fortunate that a number of sites for such camps are available, at least 500 feet away from the river, on benches, where the soil, largely gravel, is dry and porous, and hence easily drained and entirely suitable for latrines. Two camps may easily be established outside the watershed; one below the intake, and one near the power house and just over the divide, within the drainage area of the Snoqualmie; and between these two points are the several sites above mentioned, on not more than two of which should camps be established.

"At the several camps the necessary latrines should be board outhouses placed over reasonably deep pits for the reception of the discharges, which, out of abundant caution, should be disinfected by the application of milk of lime, made from freshly slaked lime, and kept protected from contact with the air. This should be prepared as often as twice per week, since with age it loses in causticity and germicidal power. As the pits become nearly filled, the filling should be completed with clean soil, and new ones should be

dug. Between camps, other latrines should be established at intervals of a few hundred feet, and portable privies may be used, which frequently should be cleaned out and disinfected.

"Rules relating to the use of these conveniences, and absolutely prohibiting the discharge of human wastes elsewhere within the watershed should be enforced with great strictness and under penalty of dismissal. It will be necessary for the future needs of the section hands and others who will constantly be employed, and of the wreckers who may be brought in from time to time as one or another cause and occasion require, to establish privies at reasonable intervals; but for the last-mentioned a portable privy carried on the train, with water-tight box or tank, would be preferable. Absolute prohibition of bathing and laundry work in the river must be emphasized.

"In order that the stretch between the intake and the power house shall receive the minimum possible amount of human wastes, it is recommended that, while trains are in the valley, all closets be kept locked and that no stops be made except in emergencies; and that no station or roundhouse be established between those points, even with the consent of the city of Seattle by ordinance, so long as the intake of the public water supply shall be below the present power house. Therefore we recommend the amendment of paragraph 2, of section 2 of the ordinance granting the right of way, by striking out the words, 'without the consent of the city of Seattle first having been granted by ordinance,' and, further, by making the prohibition a permanent restriction in the deed.

"For the most complete safeguarding of the water, it is advised that, inasmuch as the soil between the location of the line and the river is frequently impermeable, and where made up of loose stone is devoid of the qualities necessary for slow filtration, the roadbed be trenched wherever necessary or advisable, the trenches being filled with gravel and sand, and that dikes be constructed alongside the trenches wherever necessary or advisable."

Prof. Freeman makes this statement:

"First having a guaranty of the safeguards which can readily be provided and which can surely be enforced, I am led to conclude that the city of Seattle may prudently grant the desired right of way and that it would be unreasonable to withhold it, because of the waste in construction and operation, that the best possible alternative railroad location involves, and for all of which waste the commercial interests of Seattle would ultimately have to help pay.

"The risks in sanitation that will remain from the presence of the railroad after the prescribed safeguards are rigorously provided, will, I believe, be of the microscopic and academic character that we continually have to accept; indeed, it can be figured out that the chance of pollution from the railroad after providing reasonable safeguards, will not be one-tenth as great as from other sources of possible pollution in lumber camps, sawmill settlements, strollers along the stream and in the branch railroad, all of which exist today and some of which will continue to exist indefinitely, and which, taken all together, are, after all, small in proportion to those that are found along the water supplies of many cities without serious epidemics.

"Those fond of figures may be interested in the following computation:

"Suppose 1,000 different passengers per day to pass through the Cedar River watershed on the St. Paul road; this is 365,000 per year. Health statistics of Massachusetts (the most complete in the United States) show 1.24 cases of typhoid per 1,000 inhabitants per year. Convalescents and those who have the disease in a mild form, in the first week or two of the disease may travel. We can at most assume that 450 out of all these 365,000 passengers would have typhoid at some time during the year. Calling the duration of those stages of the disease within which one could travel, a month, or one-twelfth of a year, we can expect only thirty-seven persons actually in the infectious stages will travel over the road during the year.

"If these have so many as four stools per day, the chance is that in the twenty minutes (or one-seventy-second of a day) occupied by ordinary trains passing through the watershed, these thirty-seven cases would produce: Thirty-seven cases multiplied by four stools, divided by seventy-two, equals two stools per year on track; or the probability is that only two discharges per year of excreta from typhoid patients are likely to be dropped on this entire ten miles of roadbed from passengers.

"When we consider that one of the residents of a lumber camp sick with typhoid may have an average of say two stools per day (we have figured twice this for the passengers), or say at least fifty stools during his entire illness—this is twenty-five times as many as we figure out as likely to come from all the passengers in a year.

"*With 500* persons resident in the watershed, the probability is

of only .62 cases of typhoid per year among them, and, of course, most of these residents are remote from the stream.

"Figuring it in another form, and assuming the domicile in as close proximity to the stream as the track: A resident population of $\frac{2\times1,000}{50\times1.24}=32$ persons would produce the same chance of infection that will be presented by 1,000 passengers per day on the trains."

Mr. Alvord, in a final discussion of this problem, summarizes the following:

"I. That in the Cedar River watershed the city of Seattle possesses a magnificent source of water supply.

"II. That the city is not now and has not in the last few years properly protected this area from gross pollution now existent.

"III. That a virgin forest or inaccessible country does not afford ideal protection from pollution, but, on the contrary, a district easily accessible in every part and open to the publicity of frequent inspections and control offers the greatest degree of protection.

"IV. It is the settled policy, therefore, of most sanitary control of watersheds, while preventing as far as possible the growth of population and the incidental pollution therefrom, to open watersheds freely to the public observation, by creating means of access which facilitate inspection.

"V. Railroads, so far as the track and trains are concerned, are not regarded as a menace to the purity of surface waters by sanitary authorities.

"VI. It is through population and industries created by railroads that sanitary difficulties occur.

"VII. The twenty-five miles or so of railway now existing in the Cedar River watershed are in themselves no menace to the valley, but the logging camps which they serve are so conducted as to be serious pollutions in many cases.

"VIII. That the operation of a completed railway line by the Chicago, Milwaukee & St. Paul Railway Company on or near the present location can be made entirely safe by some simple precautions, such as fencing, drainage, closed bridge floors and locked water closets.

"IX. That care should be exercised during the period of construction of the railroad to prevent all access to the water by men or animals. For this purpose the river front should be entirely

fenced off, policed, and where necessary, water should be pumped up to the camps from the river under pressure, and in suitable quantities, for all purposes, including bathing, and watering animals.

"X. That efficient sanitary control should be had over all camps, cleanliness enforced, refuse of all kinds promptly collected and burned, drainage filtered and commodious and convenient sanitary arrangements provided and strict control and authority maintained.

"XI. That the city of Seattle should also fence in the road which it has constructed along the river bank between Barneston and the power house, so as to prevent access therefrom to the river.

"XII. That the city of Seattle should regulate and control by intelligent sanitary rules the various logging camps now existing upon the watershed.

"XIII. That this would be highly desirable to prevent decaying wood and vegetable matter from defacing the shores of Cedar River and its important tributaries, and cut off the swamps at the outlet of Cedar Lake and immediately above the intake."

The writer's comments on this subject are summarized as follows:

"I may briefly summarize the conditions found by myself in the Cedar River Valley and its tributaries.

1. An investigation of the biology of the water supply leads me to say that the water of the Cedar River, Cedar Lake, and some of the small tributaries, is excellent; that in some few cases pollution has been found, but that this can be remedied by a careful inspection on the part of the city and the city should consider it its first duty to order a thorough renovation of the objectionable places in the watershed of the river, particularly the bad conditions existing along Taylor Creek and the Miller Logging Camp.

2. The city should at once prohibit the roaming at large in the watershed of hogs and other live stock. These should not have access to the water, nor should the sewage from these animals pass into the water. It is also of prime importance that where villages and mill camps occur, they should have a sewage disposal system, which can be operated at a small expense and perfectly protect the watershed. I do not think that the sewage from the outhouses, etc., on the high plain above the Cedar River at Barneston will contaminate the water supply, as the sand and gravel form an excellent filter bed, though I would advise some changes there.

3. I would further recommend that the debris, logs, etc., found in the river at numerous points should be removed as soon as possible; that the material in the swamp of Cedar Lake should be cleaned out and made attractive.

4. The most dangerous time in connection with the construction of the C., M. & St. P. Railway through the watershed would be at the time when the railroad is being constructed, but sanitary science has discovered means of effectually removing all of the objectionable features connected with these camps. All of the material can be cremated and removed, so that there would be no chance for infection. The city should provide sanitary inspection at each of the camps, and furthermore a physician should be employed to give proper medical attendance.

5. The railroad in passing through the watershed should have all toilet rooms locked, and there should be no stations permitted anywhere between the power plant and the city intake; that a road running through the city watershed will add greatly to the facilities for protecting and police patrolling the district later; that because of the excellence of the filter material, consisting of sand and gravel, there would at no time be any danger from the passage of infectious material from the right of way to the water; that where the distances are fifty feet and less, the drainage should be carried to some convenient place, and there discharged into a filter bed. These filter beds are efficient in the removal of all organisms. It has been shown experimentally in numerous filtration plants in the country, where sewage is disposed of in this way, that from 99 to 99.8 per cent of the bacteria can be removed, and that the conditions existing in the Cedar River watershed would be even greater than in the figures I have here given.

6. I can see no reason why the C., M. & St. P. Railway should not be given a right of way through the Cedar River Valley, and believe it would not endanger the purity of the city's water supply.

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re I. is a cut on the Northern Pacific Railroad, near the Cedar River. A vulet runs along side of the road bed, but no washing of soil occurs; al- *the rainfall is* over *100* inches a year.

Figure II. is a forest scene. A log of Oregon Fir in the foreground. The ground is covered with humus and other organic matter. Underneath the humus sand and gravel.

re III. Outhouses over the bank of Taylor Creek, Miller's logging camp.
may thus reach Seattle water supply.

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Figure IV. On the Cedar River.
A rapid flowing stream.

ATALOGUE OF THE POISONOUS PLANTS OF IOWA.

BY L. H. PAMMEL AND ESTELLE D. FOGEL.

a number of years we have given a course of lectures on poisonous and injurious to live stock to the veterinary stu- ›f the Iowa State College.

1 stockmen and farmers in various parts of the state we fre- receive queries in regard to poisonous plants. In some cases ›ries are accompanied with specimens. We are often asked more detailed information. In many cases, however, the :e of poisoning is not proven; certain weeds are found in a › and the farmer supposes that they may be responsible for .th of animals.

literature on the subject is quite meager so far as the plants a are concerned. The government has published several dealing with this subject, of these papers I may mention ›y Chesnut[1], Chesnut and Wilcox[2], Wilcox[3], and Nelson[4]. vriters on the same subject are O'Gara[5], Kennedy[6], Peters, t Avery[7], Glover[8], Crawford[9], Heald & Peters[10], White[11], n[12], Bessey[13], Rusby[14], Guttenberg[15], Pammel[16], Mills-

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In the sequence given in the following list we have followed the Engler and Prantl die Natuerlichen Pflanzen Familien.

EUTHALLOPHYTA. Schizophyta.

SCHIZOMYCETES.

Bacteria produce disease in two ways:—*First,* as parasites when they derive their nourishment from the living animal; in this case they may cause embolism as in the case of Bacillus anthracis or toxaemia as in diphtheria bacillus; or they may produce within the body products that are poisonous. The tetanus bacillus though parasitic produces powerful poisons that when injected even in minute doses cause a fatal termination, producing all the symptoms found in animals having the disease. *Second.* many saprophytic bacteria produce poisonous substances, especially such as occur in putrid flesh, fish, and other decaying substances. The list of such organism is a long one and cannot be given in this conection.

SCHIZOPHYCEAE. OSCILLATORIACEAE.

1. Oscillaria.

Several species in the state, probably somewhat injurious.

NOSTOCACAE.

2. Nostoc caeruleum, Lyngb.
3. N. muscorum, Ag.
4. N. commune, Vauch.

Dr. J. C. Arthur some years ago thought that one of the common blue-green algae, a species of nostoc, found in lakes in Northern Iowa and Southern Minnesota, was poisonous. Its poisonous nature was not conclusively demonstrated. These algae have been suspected in other parts of the world. Mr. George Francis[1] calls attention to the Nodularia spumigena occurring in a fresh water lake in Australia. Thirty ounces of a scum fed to sheep produced death. It is also poisonous to horses, dogs and pigs. Many of the algae of this group produce very disagreeable odors when decomposition occurs, and this plant is no exception to the rule. A few of these algae may be mentioned.

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3. Anabaena stagnalis, Kg. Both of these Anabaena are found floating on e water. In their decomposition they produce pig-pen odors.

Euphyceae.

CHLOROPHYCEAE.

VOLVOCACEAE.

Pandorina. Common in stagnant pools, especially in barnyards. The water repulsive. Cattle will not drink it unless driven to do so. May be injurious. olvox may be placed in the same category.

Eumycetes.

PHYCOMYCETES.

ZYGOMYCETES.

MUCORACEAE.

The species of this order are common; among them are:

7. Mucor mucedo, found on horse manure, and

8. Rhizopus nigricans, found on decaying organic substances.

There are two recorded pathogenic species.

9. Mucor corymbifer and

10. Mucor rhizopodiformis, but these have not been reported as occurring this state.

11. Mucor stolonifer.

Common in state. Probably not pathogenic.

BASIDIOMYCETES.

Hemibasidii.

USTILAGINACEAE.

12. Ustilago maydis, D. C. Corn smut is supposed to be poisonous to ttle, but the evidence is not very conclusive.

13. Ustilago avenae, (Pers.) Jens. The common loose smut of oats is pposed to be injurious in large quantities, the same may be said of other uts occurring upon cereals. Among these are barley smut (Ustilago hordei.), (. nuda,) (U. tritici.)

14. Ustilago neglecta, Niessl.

Pigeon Grass smut is thought by many farmers in Iowa to cause poisoning,)ecially abortion. Prof. Power, formerly of the University of Wisconsin, md present in this smut a small quantity of ergotine.

TILLETIACEAE.

15. Tilletia foetens (B. & C.) Trel.

Stinking smut of wheat is not common in this state, but when it occurs in ur it causes bad odors. The spores give to the flour a dark color and make unsalable.

Eubasidii.

PROTOBASIDIOMYCETES MELAMPSORACEAE.

16. Coleosporium solidaginis (Schw.) Thum.

Parasitic on golden rod and some other plants of the order. Common in state. A number of horses in Black River Falls, Wisconsin, a few years

ago, became diseased, it is thought, by means of this rust. It may produce a form of Mycotic stomatitis.

PUCCINIACEAE.

17. Puccinia graminis, Pers.

Wheat and oat rust, especially the uredo stage, produces inflammation of the mucus membrane of the mouth and nose. The dust coming from the straw when grain is threshed often causes serious disturbances. Other rusts might be mentioned in this connection. like Puccinia coronata, Cda., the uredospores have an effect similar to that of the common grass rust.

AUTOBASIDIOMYCETES POLYPORACEAE.

18. Boletus felleus, Bull.

Probably occurs in the state. It has a bitter taste. Poisonous.

AGARICACEAE.

19. Lepiota morganii, Pk.

This fungus is very common in the fall in meadows and pastures and lawns. The cap is from five to eleven inches across. The gills or radiating plates beneath the cap are brown when mature. The lower part of the stipe is somewhat enlarged, but no cup occurs. This when eaten by some people is known to produce poisoning and even death.

20. Amanita muscaria, L.

Used to poison flies in Asia.

20a. Amanita phalloides, Fr.

This species is very poisonous and no one should eat so-called mushrooms unless they are familiar with them.

PHALLACEAE.

21. Phallus impudicus, (L.) Fries.

Is the common stinkhorn, probably poisonous, though its disagreeable odor would seem to render it distasteful to animals.

LYCOPERDACEAE.

22. Lycoperdon bovista, L.

The giant puffball is edible in fresh condition, when the flesh is white, but in the mature form is considered poisonous, the same thing applies also to other puffballs.

ASCOMYCETES ASPERGILLACEAE.

23. Eurotium herbariorum (Wigg.) Link.

This fungus is supposed to produce staggers. Frequently found in moldy hay and gives rise to digestive disorders. Mycotic stomatitis.

24. Aspergillus niger, van Tiegham.

This mold also occurs in moldy hay and other moldy substances and like the preceding species is injurious.

25. Aspergillus fumigatus, Fr.

Commonly found on decaying substances, especially moldy hay. It is pathogenic. Found in the ear of man as a parasite.

26. Aspergillus flavus, Link.

[YPOCREACEAE.

7. Claviceps purpurea, Fr.
'ound on many different grasses, especially wild rye, cultivated rye, tim- and quack grass. Produces a disease known as ergotism. The fungus ery poisonous, causes dry gangrene and abortion.

IGI IMPERFECTI:

3. Oidium albicans, Robin.
ommonly found in the mouth of sucking animals of different kinds, :ially calves.

). Fusarium. Sp.
ommonly found on moldy corn, causes derangement of the digestive or- and in some cases death.

MBRYOPHYTA ZOIDIOGAMA.

:eridophyta.

ILICALES.

OLYPODIACEAE.

). Pteris aquilina, L.
he common brake is found in eastern and northeastern Iowa. Produces :ge, strong root-stock. Said to be poisonous to cattle and horses.

1. Aspidium marginale, L.
f rare occurrence in the state. The root-stock is used as a remedy for expulsion of tapeworm and undoubtedly sometimes produces poisoning.

SMUNDACEAE.

. Osmunda claytoniana, L.
his fern is widely distributed in eastern and northeastern Iowa, occurring ar west as the Des Moines basin. The odor is not pleasant and the plant ndoubtedly more or less poisonous.

QUISETALES.

QUISETACEAE.

3. Equisetum arvense, L.
he common horse-tail is supposed to be injurious to horses, so reported 'ermont by Dr. Richman and Professor Jones, and reports of poisoning ther parts of the country are recorded. In Europe it has long been ected of being poisonous.

4. Equisetum robustum, A. Br.
; is common in the state and, like the preceding, is considered poisonous.

MBRYOPHYTA SIPHONOGAMA.

ymnospermae.

ONIFERAE.

AXACEAE.

5. Taxus canadensis, Willd. American yew.
ound in northeastern Iowa, especially on calcareous rocks and occasionally and-stone rock, *Linn, Allamakee,* and Winneshiek counties. The European *ies has long been regarded* as poisonous to stock. Cases of poisoning

have been reported in this country as well. Toxic substances, one of which is known as *taxine* $C_{37}H_{52}O_{10}N$.

PINACEAE.

36. Juniperus communis, L. Common juniper.

Poisonous, especially the oil obtained from the juniper berries. Rusby and others refer to the poisonous nature of this plant, and Schaffner records that goats are poisoned by eating the leaves. Common only in lime and sandstone rocks in Northeastern Iowa, also Hardin and Linn counties.

37. Juniperus virginiana, L. Red Cedar.

Common in Northeastern and Eastern Iowa, but also widely scattered in the state. The leaves contain the same principle found in the juniper, and according to Schaffner, are poisonous to goats. The oil produces abortion and poisoning has resulted from its use. The oil of Cedar has well known antiseptic properties. An aromatic body cedren $C_{15}H_{24}$, oil of cedar from which cedren-camphor $C_{15}H_{26}O$ has been obtained.

38. Juniperus scopulorum. Sarg.

Commonly cultivated in the state, probably poisonous, like the preceding.

39. Juniperus sabina, L. Swedish juniper.

Occasionally cultivated in the State. Poisonous, like the preceding species.

MONOCOTYLEDONAE.

HELOBIAE. ALISMACEAE.

40. Alisma plantago, L. Water plantain.

Recorded as being poisonous.

41. Sagittaria latifolia, Willd. Large arrow head.

The milky juice is somewhat bitter. The plant is edible, when cooked. The root stocks of several species of the genus are eaten by the Indians and in China.

GLUMIFLORAE. GRAMINEAE.

42. Andropogon sorghum, Brot. Sorghum.

Second growth sorghum has frequently been reported as poisonous to live stock; this is due to the formation of hydrocyanic acid in the wilted leaves.

43. Setaria italica, Kunth. Millet.

Both the German Millet and the Hungarian Grass are poisonous to horses, acting especially on the kidneys. The poisoning is probably due to a glucoside.

44. Stipa spartea Trin. Needle Grass, or Porcupine Grass.

The sharp pointed callus often inflicts serious injuries; the fruits work their way under the cuticle into the flesh of the animals, and in some instances they have even penetrated the intestines.

45. Stipa comata, Trin. Western needle grass.

Somewhat injurious, like the preceding. Only found in N. W. Iowa.

46 Stipa viridula, Trin. Sleepy grass.

This grass has been introduced here and there in the state, and has been suspected of producing stupor in horses. It is doubtful whether this is the one usually referred to in the west as the sleepy grass.

47. Avena sativa, L. Common oats.

The chaff of this grass sometimes produces balls in the stomachs of horses, known as phytobezoars.

48. Avena fatua, L. Wild oats.

Common only in a few counties in northern Iowa. Sometimes causes mechanical injuries on account of the pointed callus of the fruit.

49. Lolium temulentum, L. Darnel.

The grain of this grass is injurious when ground in with flour. It produces stupor and symptoms resembling drunkenness. The poisoning is due to the fungus found in the seed. Principle *loliin* a glucoside.

50. Hordeum vulgare, L.

The chaff and awns of barley are often injurious, especially when coming in contact with the mucous membrane, not only in man, but in lower animals.

51. Hordeum jubatum, L. Squirrel-tail. Wild Barley.

Common throughout the state. This grass produces mechanical injuries in animals that feed on hay containing it, the awns working their way in between the teeth and maxillae. where they cause inflammation and the formation of pus.

52. Agropyron repens, Beauv. Quack grass.

Widely distributed in northern Iowa. Produces a slight irritation of the mucous membrane. Contains *triticin* $C_{12}H_{22}O_{11}$.

LILIIFLORAE. LILACEAE.

53. Zygadenus elegans, Ph. Swamp camas.

Common in northern Iowa. In the western states it is regarded as poisonous to cattle and sheep, occasionally causing death. It is not as poisonous as some of the other species of the genus.

54. Arisaema triphyllum, Torr. Jack-in-the-pulpit.

It is widely distributed in the state. The corm is known to be very acrid and poisonous, but when boiled or roasted the poisonous substance is expelled.

55. Arisaema dracontium, Schott. Dragon's-head.

Widely distributed, especially in eastern and central Iowa. The corm is somewhat acrid. The corm is used to destroy insects, said to be a good vermifuge. The action of the plant in fresh condition is somewhat similar to ammonia.

56. Symplocarpus foetida, (L.) Raf. Skunk Cabbage.

Local only in a very few places. Said to be poisonous, causes vomiting, and temporary blindness. The juice is acrid and the plant has a very disagreeable odor.

57. Melanthium virginicum, L. Bunch-flower.

Common only on low grounds in eastern Iowa. The root stocks are regarded as poisonous, but reports have come to us of the poisonous effect of the leaves and stems on horses, when occurring in hay.

58. Veratrum woodii, Robb. False Hellebore.

Found in Southeastern Iowa. Poisonous like the eastern white Hellebore and the western California Hellebore. Probably contains *jervine* $C_{21}H_{27}NO_3$, and cevadina $C_{32}H_{49}O_9$ and cevadine $C_{27}H_{43}NO_2$.

59. Allium canadense, L. Wild onion.

Widely distributed; common in low pastures. Milk is flavored where cattle feed on the plant.

60. Allium tricoccum, Ait. Wild Leek.

Eastern and northeastern Iowa, seldom west of the Iowa river. Taints milk like the preceding.

61. Lilium superbum, L. Turk's-cap lily.

According to Schaffner, this species produces dermatitis. The bulbs produce mental exhaustion and headache.

62. Asparagus officinalis, L. Asparagus.

According to Dr. White, in his Dermatitis Venenata, persons who constantly work with asparagus may have the skin somewhat blistered.

63. Convallaria majalis, L. Lily-of-the-valley.

All parts of this plant are very poisonous to man and domestic animals. Contains two glucosides, *convallamarin* $C_{46}H_{44}O_{24}$, and *convallarin* $C_{34}H_{31}O_{11}$.

64. Trillium grandiflorum, Salisb. Large flowered Trillium.

This is used as an emetic and contains a principle which has been called trilline, found in a few other species of the genus.

65. Trillium erectum. L. Erect Wake-robin.

The root stock of this species is somewhat poisonous.

66. Smilax rotundifolia, L. Round-leaved Greenbrier.

Widely distributed in the state. Dr. Schaffner reports a case of poisoning from eating the young leaves of these plants. The spines are injurious in a mechanical way; they cause inflammation and pus formation.

IRIDACEAE.

67. Iris versicolor, L. Large Blue-flag.

The underground root stocks of this plant are known to be very poisonous. Dr. Rusby thinks there is some danger "that it might be eaten in mistake for Calamus, which is commonly known as Sweet-flag. If so, it would prove seriously if not fatally poisonous, as its well-known emetico-cathartic properties, even when toned by drying and keeping, are powerful, and in a fresh state would be decidedly violent." It contains the resinous body *iridin.*

MICROSPERMEAE.

ORCHIDACEAE.

68. Cypripedium spectabile, Swz. Showy Moccasin flower.

Produces dermatitis resembling that produced by Poison Ivy. A great many persons are more or less susceptible to this form of dermatitis. Not abundant in Iowa.

69. Cypripedium pubescens, Willd. Yellow Lady-slipper.

Poisonous like the preceding. This species is more widely distributed.

70. Cypripedium candidum, Muhl. Small white Lady-slipper.

Poisonous like the preceding. At one time common in marshes in the state, but rapidly disappearing. Less poisonous than the preceding species.

DICOTYLEDONEAE.

JUGLANDACEAE.

71. Juglans nigra, L. Black Walnut.

It is commonly believed that the bitter principle *Juglandin* found in the fruit and leaves of the black walnut are more or less poisonous, at least it is thought that different species may poison the soil and prevent the growth of other plants; this is, however, not well substantiated. Probably contains *nucin,* an acrid body, causes irritation resembling scarlatina.

URTICALES.

URTICACEAE.

72. Maclura aurantiaca, Nutt. Osage orange.

Cultivated especially in the southern part of the state. The leaves and ruit are more or less poisonous. The thorns upon the plant produce serious njuries giving rise to inflammation.

73. Humulus lupulus, L. Common Hop.

Hop pickers often have an inflammation of the hands. It is a sedative. Iop contains *choline* $C_5H_{15}NO_2$, lupulic acid $C_{32}H_{50}O_7$, oil of humulus $C_{10}H_{16}$ and $_{10}H_{16}O$.

74. Cannabis sativa, L. Hemp.

Naturalized in many parts of the state. The narcotic effect of the resin of ne plant is well known and in India an intoxicating drink is made from the uice of the leaves. Probably it contains the substance *cannabin*, oxycannabine $_{20}H_{20}N_2O_7$ and cannabine $C_{18}H_{20}$.

75. Urtica dioica, L. Stinging nettle.

The urticating properties of our common nettle are known to all who have ad any experience in collecting the plants; there is at first a reddening, folwed by a swelling, intense burning, and a small amount of itching. It ntains formic acid H_2CO_2.

76. Urtica gracilis, L. Slender nettle.

Injurious, like the preceding. More widely distributed than the preceding.

77. Laportea canadensis, Gaud. Wood nettle.

This plant is even more widely distributed than the preceding nettles. It found in deep woods. Produces an irritation of the skin like common nettle.

POLYGONALES.

POLYGONACEAE.

78. Rumex acetosella, L. Sheep sorrel.

The plant is widely distributed over the state and is becoming more comon. Said to be poisonous to horses and sheep. Contains oxalic acid.

79. Fagopyrum esculentum, Moench. Buckwheat.

A dermatitis produced by the eating of buckwheat cakes is well known to ost people and occasionally where screenings of this material are fed in iantities to hogs a similar rash is produced. Buckwheat straw is also condered poisonous. The plant contains the glucoside *indican*.

80. Fagopyrum tartaricum, Gaertn.

Poisonous like the preceding.

81. Polygonum acre, H B K. Smartweed.

The acrid properties of many of the species of Polygonaceae are well known. his species is widely distributed in the state. Contains probably *polygonic id.*

82. Polygonum hydropiper, L. Smartweed.

Poisonous like the preceding.

CENTROSPERMEAE.

CHENOPODIACEAE.

83. *Chenopodium* anthelminticum, L. Worm-seed.

Occasionally reported in the state. Cases of poisoning from the oil of the seeds have been reported in medical literature. Contains the volatile oil of worm-seed. This is a narcotico-acrid poison.

84. Chenopodium ambrosioides, L. Mexican Tea.

This species is occasionally reported with properties like the preceding.

PHYTOLACCACEAE.

85. Phytolacca decandra, L. Pokeweed.

The roots and seed contain a very poisonous substance. The young shoots are eaten as greens; probably the poisonous principle is dissipated on boiling the plant. Found only in southern Iowa. Contains *phytolaccine*.

CARYOPHYLLACEAE.

86. Stellaria media, L. Chick-weed.

This has been reported as poisonous, although the seeds are eaten by birds.

87. Agrostemma githago, L. Corn cockle or cockle.

Generally found in wheat fields. Screenings are often sold as stock food and several cases of poisoning from food that contained screenings of cockle have been reported to me. When cockle is in flour, it is poisonous. Several cases of poisoning from flour containing cockle are on record. Cockle is said to be especially poisonous to poultry. Contains the glucoside *saponin* $C_{32}H_{54}O_{18}$ *sapogenin* $C_{14}H_{22}O_2$, and the alkaloid *agrostemmine*.

88. Silene antirrhina, L. Sleepy catchfly.

Very widely distributed in the state. Said to be poisonous.

Silene noctiflora, L. Evening catchfly.

Widely distributed in eastern Iowa. Native to Europe, probably also poisonous.

89. Saponaria officinalis, L. Bouncing Betty.

This plant is said to be somewhat poisonous. Naturalized here and there in the state.

90. Vaccaria vulgaris, Host. Cow cockle.

Common only in grain fields, seeds said to be poisonous, like corn cockle.

RANALES.

NYMPHAEACEAE.

91. Nelumbo lutea, Pers. The American Nelumbo.

Root stocks were used by the Indians for food. It is said to be used to destroy cockroaches according to Schaffner. Roasting dispels the poisonous principle.

RANUNCULACEAE.

92. Hydrastis canadensis, L. Orange Root. Golden Seal.

In northeastern Iowa. Contains *hydrastine* $C_{22}H_{23}NO_6$, *berberina*, *berberinum* and *xanthopuccina*. Hydrastis causes severe ulceration and cattarhal inflammation.

93. Caltha palustris, L. Marsh marigold.

The leaves of the marsh marigold are eaten, but the poisonous principle is dissipated on boiling. Plant found on low grounds, especially in northern Iowa.

94. Actaea alba, Mill. White baneberry.

More or less poisonous, but generally not eaten by live stock. Found in oods more or less widely distributed in northern Iowa.

95. Actaea rubra, Willd. Red baneberry.

Widely distributed in the state, but never abundant. Berries poisonous.

96. Delphinium consolida, L. Field larkspur.

Naturalized from Europe. Poisonous and fatal to cattle, frequently cultiated as an ornamental plant. It contains several poisonous alkaloids. The kaloids *delphinine* $C_{22}H_{35}NO_6$, *delphisine* $C_{27}H_{46}N_2O_4$, *delphinoidine* $C_{42}H_{68}N_2O_7$, nd *staphisagrine* $C_{22}H_{35}NO_5$ occur in D. Staphisagria and may be looked for ı some of our larkspurs.

97. Delphinium carolinianum, Walt. Carolina Larkspur.

Native to prairies, especially gravelly knolls. Reported as fatal to cattle.

98. Delphinium exaltatum, Ait. Tall Larkspur.

Frequently cultivated, native to Europe.

99. Delphinium tricorne, Michx.

Produces fascicled tuberous roots. Common in southern Iowa. Very poionous to cattle.

100. Aconitum uncinatum, L. Wild Monk's-hood.

Native to a limited area in northeastern Iowa. Contains the substance .conitin. Root, flowers and leaves are poisonous.

101. Anemone nemorosa, L. Wood Anemone.

The common wind flower is said to be a local irritant.

102. Anemone patens, var. Nuttalliana. Gray, Crocus. Sorrel flower. Pasque flower. Wind flower.

This plant is local in central and southern Iowa, but in northern Iowa it s common on gravelly knolls. It is a well known irritant, contains the bitter ubstance *anemonin* $C_{15}H_{12}O_6$.

103. Clematis virginiana, L. Virgin's-bower.

This plant is widely distributed in the state along with other species of the ame genus. The herbage is said to be acrid and caustic. The juice of some pecies of the genus causes blisters, or even ulcers. The fresh leaves of the C. *erecta* are used as a vesicant in Europe, especially by beggars, hence sometimes called beggar's weed.

104. Ranunculus abortivus, L. Crowfoot.

Common weed in many parts of the state. The leaves are quite acrid; they have a sharp, peppery taste.

105. Ranunculus sceleratus, L. Cursed crowfoot.

A very poisonous species, especially to cattle, since it grows in marshes along with other herbage and is often eaten along with other forage plants. Contains *anemonol* and anemoninic acid.

106. Ranunculus acris, L. Tall buttercup.

Poisonous, causes inflammation when it comes in contact with mucous membrane. Rarely found in the state, but sometimes naturalized.

107. Ranunculus septentrionalis, Poir. Creeping Buttercup.

Widely distributed in low grounds. Acrid like the preceding species.

108. Ranunculus fascicularis, Muhl. Tufted buttercup.

Found only in eastern Iowa, as far west as the Iowa River. Probably poisonous like the preceding species.

ANONACEAE. Custard Apple Family.

109. Asimina triloba, Dunal. Papaw.

It occurs in eastern Iowa as far north as Clinton and Dubuque. The pawpaw is commonly eaten, but a case of poisoning is reported.

BERBERIDACEAE.

110. Berberis aquifolium, Pursh. Trailing Mahonia.

Cultivated. Poisonous. According to Schaffner, the berries are injurious to birds. Probably contains the alkaloids *berberine* $C_{20}H_{17}NO_4$ and oxyacanthine $C_{32}H_{46}N_2O_{11}$, which occurs in the common barberry.

111. Podophyllum peltatum, L. May Apple or Mandrake.

This plant is widely distributed east of the Missouri divide. The roots and leaves are drastic and are known to be poisonous. It is said also that when the leaves are eaten by cows, they produce injurious milk. Dr. Rusby states "a fatal case is recorded in which the evidence is perfectly clear that poisoning resulted from continued large doses administered by an ignorant and careless physician. The poisonous symptoms were all referable to the bowels, those of enteritis. It is also very interesting to note the peculiar effects of poisoning of the external skin by the powder and by the resin of this plant. It produces an ulcer of a very peculiar character, closely resembling one of venereal origin. Serious errors of diagnosis, leading to the gravest injustice to the reputation of the patient, have been known to occur in reference to these cases. A very serious ulcer upon the eye-ball is among these recorded cases." The roots, according to Dr. White, are irritating to the eye, nose, and mouth and skin. Contains picropodophyllin $C_{11}H_8O_2+H_2O$, podophyllotoxin $C_{11}H_1O_2$. The *podophyllin* is a resinous mixture.

MENISPERMACEAE.

112. Menispermum canadense, L. Canadian Moonseed.

This plant is widely distributed in woods in Iowa. According to Dr. Schaffner, contains menispermine, and menispine. A case is reported of the death of three boys from eating the berries in mistake for grapes. The *Cocculus indicus* is a well-known remedy for the destruction of pediculi and is known to be poisonous. It contains *picrotoxin* $C_{30}H_{31}O_{13}$, *cocculin* $C_{19}H_{26}O_{10}$ and an alkaloid *menispermine* $C_{18}H_{24}N_2O_2$.

CALYCANTHACEAE.

113. Calycanthus floridus, L.

Cultivated in Southern Iowa. The aromatic properties of the flowers resemble those of strawberries. This makes it a very desirable cultivated ornamental plant. It contains an active principle *calycanthine*. Chesnut records it as poisonous.

LAURACEAE.

114. Sassafras officinale, Nees. Sassafras.

The berries of this plant are reported to be poisonous, according to Schaffner. This species is found native only in southeastern Iowa.

RHOEDALES. PAPAVERACEAE.

115. Papaver somniferum, L. Opium.

Opium is obtained from the common garden poppy. This species is widely *cultivated in the* state, and is frequently spontaneous. The more common

alkaloids found in the poppy plant are *morphine* $C_{17}H_{19}NO_3 + H_2O$, *codeine* $C_{18}H_{21}NO_3+H_2O$, and *narcotine* $C_{22}H_{23}NO_7$. The seeds of poppy are sometimes used to spread on top of cookies and bread.

116. Papaver rhoeas, L. Corn Poppy.

This species is occasionally cultivated and sometimes spontaneous; the milky juice contain some poisonous alkaloids, *papaverine* $C_{20}H_{21}NO_4$; codeine $C_{18}H_{21}NO_3$.

117. Papaver dubium, L. Long Smooth-fruited Poppy.

Cultivated; native to Europe, naturalized in Eastern North America.

118. Papaver orientale, L.

This handsome, showy plant is frequently cultivated for ornamental purposes and contains a large amount of milky juice. This plant must be recorded as suspicious.

119. Argemone mexicana, L. Mexican Prickly Poppy.

The Mexican prickly poppy, with pale yellow or yellowish petals, is cultivated in gardens. The latex not only contains narcotic principles, but the prickly pods sometimes cause mechanical injury and set up inflammation. The latex contains morphine.

120. Argemone platyceras, Link & Otto.

This prickly poppy of the plains contains a narcotic substance in its latex. The prickly leaves of the plant cause serious mechanical injury and inflammation.

121. Sanguinaria canadensis, L. Bloodroot.

This widely distributed plant of Eastern North America is well known to nearly everyone. The root is poisonous, contains the principle sanguinarina, found in the red latex. The root is sharply irritating, especially to mucous surfaces. Contains the alkaloid sanguinarine $C_{21}H_{15}NO_4$.

122. Chelidonium majus, L.

Celandine is occasionally cultivated and sometimes spontaneous. The orange-yellow juice or latex is an irritant. The fresh juice produces inflammation and blisters, and it poisons the skin if handled so as to crush the leaves or stem. Contains *chelerythrine* $C_{21}H_{17}NO_4$, with a burning taste, and glaucine $C_{18}H_{19}NO_4$.

CRUCIFERAE.

123. Lepidium sativum, L. Garden Pepper-grass.

Native to Europe, but occasionally escaped from cultivation. The Garden Cress is used as greens. It is a local irritant.

124. Lepidium apetalum, Willd. Small Pepper-grass.

Widely distributed in this state, and like the other pepper-grasses, may produce sinapism.

125. Nasturtium armoracia, Fries. Horse-radish.

This is poisonous, like the preceding species of this order that have been mentioned. Dr. Rusby refers to its irritating properties when taken in excess especially because of its action upon the urinary organs. One case referred to by Dr. Johnson was extreme and serious.

126. Sisymbrium officinale, Scop. Hedge Mustard.

This plant is widely distributed in this state, as a weed. Produces more trouble than mustard.

127. Sisymbrium altissimum, L. Tumbling Mustard.

Weed common in grain fields in the north and may thus find its way into wheat screenings. Such screenings should be fed with caution. Probably produces sinapism, as the other plants of the order. It is also found in this state.

128. Brassica sinapistrum, Boiss. Charlock.

This weed produces sinapism. After the application of the powdered material, there is a sense of burning. The volatile oil of mustard is a powerful irritant, and caustic, and should be used with caution.

SARRACENIALES. SARRACENIACEAE.

129. Sarracenia purpurea, L. Side-Saddle Flower.

Probably not native to the state, although it is found distributed with Drosera in LaCrosse County, Wisconsin, and formerly also in Houston County, Minnesota. The plant contains the substance *sarracenin*. The root produces diuresis, gastric excitation, and an increased, irregular action of the heart. It produces papular eruptions changing to vesicular with depression as in small-pox. The plant was formerly used medicinally by the Indians.

DROSERACEAE.

130. Drosera rotundifolia, L. Sundew.

Sundew is said to be poisonous to cattle. It is not known to be native to the state, although it occurs in Western Wisconsin, north of the Iowa line, and also in Houston County, Minn.

ROSALES. SAXIFRAGACEAE.

131. Sedum acre, L. Stone Crop.

Produces inflammation when applied to the skin of many persons. The juice is acrid and biting.

ROSACEAE.

132. Fragaria vesca, L. European Strawberry.

Found on sand-stone and limestone rocks. Produces irritation of the stomach in some people.

133. Fragaria virginiana, Mill. Wild Virginia Strawberry.

Similar to the preceding.

134. Fragaria chiloensis, Duchesne. Cultivated Strawberry.

Like the preceding. I have known people who could not eat strawberries or pick them without being irritated.

135. Rosa arkansana, Porter. Arkansas Rose.

Widely distributed in the state, especially prairie regions. Not poisonous, but the bristles and prickles often enter the skin and produce serious inflammation.

136. Rosa rubiginosa, L. Sweetbriar.

A frequent escape in pastures. The recurved spines and prickles are injurious like the preceding species.

137. Pyrus aucuparia, Meyer. Mountain Ash.

The berries are poisonous to man, but not to birds. However, they are readily disseminated by birds.

138. Pyrus communis, L. Pear.

Dr. Schaffner states that horses are reported to have been killed by eating rotten pears.

139. Pyrus malus, L. Apple.

The seeds are poisonous; they contain the glucoside which is changed into hydrocyanic acid.

140. Crataegus mollis, L. Haw.

Cases of poisoning are reported by persons eating the fruit of *Crataegus mollis*, probably more on account of the inedible seeds than the fruit.

141. Prunus americana, Marsh. Wild Plum.

The shoots and seeds contain the principle *amygdalin* which is converted into hydrocyanic acid, which is a deadly poisonous substance. The fruit, it should be said, is entirely harmless.

142. Prunus pumila, L. Sand Cherry.

This cherry is not widely distributed in the state, found along the Missouri river and in sandy soil in Eastern Iowa. The fruit is slightly acid and somewhat astringent. Not poisonous, except the wilted leaves and the seeds. The astringent qualities in our wild fruit are undesirable.

143. Prunus pennsylvanica, L. Wild Red Cherry.

Common, especially in the eastern part of the state, and northern as far as Boone and Story Counties. The leaves are poisonous, as well as their seeds. The fruit is edible.

144. Prunus virginiana, L. Choke Cherry.

The leaves and seeds are poisonous. The fruit is astringent, so great is this astringency that it often produces very unpleasant conditions when eaten in any considerable quantity. Choke Cherry is rather widely distributed in the state. The leaves in the wilted condition contain *hydrocyanic* acid HCN.

145. Prunus serotina, Ehrh. Wild Black Cherry.

Most poisonous species in the state. The half wilted leaves are much more poisonous than the fresh leaves, and the seed are very poisonous. The poisonous substance produced is hydrocyanic acid HCN.

146. Amygdalus persica, L. Peach.

The leaves and seeds are poisonous. They contain the substance amygdalin, from which hydrocyanic acid is derived.

LEGUMINOSAE.

147. Cassia chamaecrista, L. Partridge Pea.

Widely distributed in the state, especially on sandy, gravelly soils. There was reported to one of us a case where a great many sheep had the scours; this ailment was attributed to this plant. Many of the species of the genus are known to be laxative.

148. Cassia marylandica, L. Wild or American Senna.

Found in the southeastern part of the state, and probably acts like the preceding.

149. Gymnocladus canadensis, Lam. Kentucky Coffee-tree.

This is widely distributed in the state, especially along the river courses in Eastern Iowa, although growing as far north as Sioux City in the northwestern part of the state, and along the Mississippi into Minnesota. The fruit contains a sweetish, but disagreeable pulp which, as well as the leaves, is poisonous. In the South the leaves are used as fly poison.

PAPILIONACEAE.

15. Baptisia leucantha, T. & G. Large White Wild Indigo.

Widely distributed in prairies of this state, is generally avoided by stock. Two eastern species are regarded as poisonous, being emetics. It is probable that this species must be regarded as suspicious.

151. Crotalaria sagittalis, L. Rattle-box.

This is found in the western part of the state in the Missouri River Bottoms. Produces a disease known as the Missouri Bottom disease, also as crotalism, by Dr. Stalker. The seeds contain an unnamed alkaloid found by Dr. Power. The plant is not only poisonous in the meadow, but also in hay.

152. Lupinus albus, L. Lupine.

The European lupine is occasionally cultivated and in Europe it produces a disease known as lupinosus. Our native species, L. perennis, is also regarded as poisonous. Contains *lupinin* $C_{29}H_{32}O_{16}FH_2O$; *lupinidine* $C_8H_{15}N$; *lupinine* $C_{21}H_{40}N_2O_2$.

153. Melilotus alba, Desv. White Sweet clover.

Widely distributed in the state as a weed. The honey bees collect considerable quantities of honey from the Sweet Clover blossoms. It has been looked upon with suspicion. Dr. Schaffner states that the seeds impart a foul odor to the flour.

154. Melilotus officinalis, Willd. Yellow Sweet Clover.

Also widely distributed in the state. Objectionable like the preceding.

155. Trifolium incarnatum, L. Italian or Crimson Clover.

According to Coville, produces "hair" balls. This plant is occasionally cultivated as a cover crop in this state.

156. Tephrosia virginiana, Pers. Goat's Rue.

Growing only in sandy soil in the eastern part of the state. Used by Indians as a fish poison. Several other species in South America and Mexico have been used in a similar way. One is called *T. toxicaria,* and is a well known fish poison.

157. Robinia pseudacacia, L. Locust-tree. Black locust.

This plant is frequently cultivated in the state, and in numerous places is an escape from cultivation. The roots, leaves and bark are very poisonous to man. Contains robinin $C_{25}H_{30}O_{16}+5\frac{1}{2}H_2O$.

158. Robinia viscosa, Vent. Clammy locust.

Cultivated as an ornamental plant; the roots are somewhat poisonous.

159. Oxytropis lamberti, Pursh. Stemless Loco Weed.

Found in the western part of this state, along the Missouri River and its tributaries, very abundant. One of the conspicuous loco or crazy weeds of the West.

160. Vicia sativa, L. Common Vetch.

A frequent weed in grain fields. The seeds of this are said to be injurious to pigs. It is not injurious to cows. Contains vicine $C_{28}H_{51}N_{11}O_{21}$.

161. Phaseolus lunatus, Linn. Lima bean.

Investigations carried on in Europe seem to indicate that the lima bean leaves in the wilted condition contain hydrocyanic acid. According to Guignard practically all varieties, whether wild or cultivated, were found to contain a principle which when acted upon by an enzyme yields hydrocyanic cacid. Pro-

›nged boiling, however, extracts the greater part of it, but it is not destroyed, ›nsequently this water should not be used, as it contains the substance hich is converted into hydrocyanic acid.

GERANIALES. OXALIDACEAE.

162. Oxalis violacea, L. Wood Sorrel.

Dr. Schaffner reports a case of a boy who was poisoned from eating a conderable quantity of the leaves. The leaves are frequently eaten.

LINACEAE.

163. Linum usitatissimum, L. Flax.

Said to produce death to cattle, probably due to the formation of hydroyanic acid in the wilted leaves. People working with the fiber of the plant ften have a form of dermatitis. The Flax-seed, when fed in considerable uantities to live stock, especially hogs, produces death. The *Linum cathartum* contains a bitter principle *linin*, and *linamarin.*

164. Linum rigidum, Pursh. Large-flowered Yellow Flax.

This plant is reported as poisonous to sheep in some parts of the country. ound in the western part of the State.

SIMARUBACEAE.

165. Ailanthus glandulosa, Desf. Tree-of-Heaven.

This plant is occasionally spontaneous in the southeastern part of the State, here it is cultivated as an ornamental plant. It is supposed to produce poining when people come in contact with it. The odor of the flowers is very sagreeable. It is said also, according to Dr. Rusby, that the water coming contact with the leaves is poisonous.

POLYGALACEAE.

166. Polygala senega, L. Seneca Snakeroot.

The roots of this plant are used in medicine as an emetic. The plant is ›mmon in the Eastern part of the state.

EUPHORBIACEAE.

167. Croton capitatus, Michx. Hogwort, Croton.

Native to Southeastern Iowa. Many species of the genus contain very ›tive poisonous principles. While this plant has not been suspected, the ›lated species, *C. texensis*, is known to be poisonous.

168. Ricinus communis, L. Castor-Oil Plant.

Widely cultivated as an ornamental plant. The seeds contain a deadly poi›nous substance *ricin.*

169. Euphorbia corollata, L. Flowering Spurge.

Widely distributed in the state, upon sandy or gravelly soil. Produces inammation of the skin.

170. Euphorbia preslii, Guss. Spurge.

Widely distributed in meadows and fields. It has been sent to the writer ; supposedly poisonous to live stock.

171. Euphorbia marginata, Pursh. Snow-on-the-Mountain.

The honey coming from the plant is poisonous. The milky juice produces ›rmatitis. At one time the plant was used for branding cattle.

172. Euphorbia lathyris, L. Caper or Myrtle Spurge.

Native to Europe, occasionally cultivated. The seeds of this plant are poisonous. The Euphorbia resinifera contains *euphorbon* $C_{15}H_{24}O$.

173. Euphorbia cyparissias, L. Cypress Spurge.

Frequently escaped from cultivation, especially near cemeteries. Poiosnous to the skin, produces a dermatitis.

SAPINDALES. ANACARDIACEAE.

174. Rhus toxicodendron, L. Poison Ivy.

The leaves and stems are poisonous to many people. The form of dermatitis produced, and the seriousness of the case varies according to the susceptibility of the individual. The plant is widely distributed in the state.

CELASTRACEAE.

175. Celastrus scandens, L. Climbing Bittersweet.

The aril is red and has a somewhat disagreeable, sweetish taste. The leaves are said to be poisonous to horses. Bittersweet is quite widely ditributed in Iowa.

HIPPOCASTANACEAE.

176. Aesculus hippocastanum, L. Horse-Chestnut.

The seed of this species has long been recognized as poisonous in Europe. Frequently cultivated in the state, especially Southern Iowa. The glucosides *aesculin* $C_{15}H_{16}O_9 1\frac{1}{2}H_2O$, *argyraescin* $C_{27}H_{42}O_{12}$.

177. Aesculus glabra, Willd. Ohio Buckeye.

Found in Southern Iowa, along river courses as far north as Fort Dodge. Cases of poisoning have been reported to one of us, especially where cattle eat the young shoots and seeds of the plant.

BALSAMINACEAE.

178. Impatiens fulva, Nutt. Spotted Touch-me-not.

Widely distributed in the state, especially low grounds. The leaves are acrid. The plant is suspected of being poisonous to live stock.

RHAMNALES. RHAMNACEAE.

179. Rhamnus cathartica, L. Buckthorn.

Frequently cultivated. Used as a hedge plant. Chiefly in Eastern and Southeastern Iowa. Ripe fruit is said to be poisonous. Contains the glucosides *rhamnin* $C_{23}H_{28}O_{14}$, *rhamnetin* $C_{23}H_{16}O_{11}$ and *rhamno-cathartin.*

180. Rhamnus lanceolata, Pursh. Buckthorn.

Native to southern Iowa, occurs as far north as Boone County. Has the same properties as the preceding species.

VITACEAE.

181. Ampelopsis quinquefolia, Michx. Virginia Creeper.

The fruit is looked upon with suspicion by some people, but there are no records of poisoning, so far as we know.

MALVALES. MALVACEAE.

182. Abutilon avicennae, Gaertn. Velvet-Leaf. Indian Mallow. Butter Print.

Widely naturalized in the state. The plant gives off a very disagreeable odor, and is suspected of being poisonous.

PARIETALES. HYPERICACEAE.

183. Hypericum maculatum, Walt. Spotted St. John's-Wort.

All the species are suspected of being poisonous to horses.

184. Hypericum perforatum, L. Common St. John's-Wort.

Naturalized here and there in Eastern Iowa.

185. Hypericum ascyron, L. Great St. John's-Wort.

Most widely distributed species in the state, woods or borders of woods.

VIOLACEAE.

186. Viola odorata, L. Sweet Violet.

Commonly cultivated in greenhouses. Said to be somewhat poisonous. Underground parts of the plant are emetic.

187. Viola cucullata, Ait. Common Blue Violet.

The most widely distributed species in the states. The roots, like the preceding, are emetic.

LOASACEAE.

188. Mentzelia ornata, Torr. & Gray. Mentzelia.

The backwardly barbed trichomes sometimes produce mechanical injuries. Found in Northwestern Iowa on the Big Sioux near Sioux City.

OPUNTIALES. CACTACEAE.

189. Opuntia rafinesquii, Engelm. Cactus.

Found in sandy soil in the state. The barbed trichomes cause mechanical injuries.

MYRTIFLORAE. THYMELACEAE.

190. Daphne mezereum, L. Spurge Laurel.

This is a well known poisonous plant of Europe. It is occasionally cultivated in the state. Contains the glucosides *daphnin* $C_{30}H_{34}O_{19}$, *daphnetin* $2(C_9H_6O_4)H_2O$, *coccognin* $C_{20}H_{22}O_8$.

191. Dirca palustris, L. Leather-Wood. Moose-Wood.

Found in Northeastern Iowa, Hardin and in Dallas Counties. The bark is acrid, the berries are narcotic and poisonous.

UMBELLIFLORAE. ARALIACEAE.

192. Aralia spinosa, L. Hercules' Club.

Occasionally cultivated. Produces mechanical injury by irritating the skin.

UMBELLIFERAE.

193. Conium maculatum, L. Poison Hemlock.

Probably introduced here and there in the state. The plant contains the alkaloids *coniine* $C_8H_{17}N$, *conydrine* $C_8H_{17}NO$, *menthylconiine* $C_9H_{17}N$, a bitter principle *cicutoxin*. A very poisonous plant both to man and lower animals.

194. Petroselinum sativum. Parsley.

Some people are suspicious of parsley. Dr. Schaffner states that the seeds are injurious to birds. He reports a case of poisoning of several parrots from eating the leaves of this plant.

195. Apium graveolens, L. Celery.

I know of several cases where persons who have handled celery have had a form of dermatitis. Some persons cannot eat celery because a rash forms.

196. Cicuta maculata, L. Water hemlock.

The roots of this plant are very poisonous. The plant is widely distributed in the state, especially in low grounds in northern Iowa. The European cowbane, *C. virosa,* contains the alkaloid *coniine* $C_8H_{17}N$, a substance which probably also occurs in our plant.

197. Cicuta bulbifera, L. Bulb-bearing Hemlock.

The roots of this, and the whole plant are supposed to be very poisonous. Occasionally found in swamps in northern Iowa.

198. Sium cicutaefolium, Gmelin. Water Parsnip.

Common in many parts of the state in low grounds. Said to be poisonous.

199. Aethusa cynapium, L. Fool's Parsley.

A poisonous herb native to Europe, with a disagreeable odor. Possibly occurs in a few places in the state. Contains the alkaloid *synapine* and another coniine like alkaloid.

200. Angelica atropurpurea, L. Purple-stemmed Angelica.

Found in low grounds in North and Northeastern Iowa. Possibly poisonous. Cattle do not relish it.

201. Tiedemannia rigida, Coult. & Rose. Cowbane.

The roots are tuberous and poisonous. It grows in swamps.

202. Pastinaca sativa, L. Parsnip.

Persons are often poisoned by handling the plant, which causes inflammation and vesication. Mr. F. C. Stewart, in a letter to the writer, made the following statement: "Henry Van Dresser, a prominent lecturer on poultry in this state, New York, had a very serious injury to his face and eyes. His face became badly swollen and his eyes were in a terrible condition. It was feared at the time that they would be ruined, but the sight was not lost, although it was considerably impaired. The physician in charge diagnosed it as a case of poisoning, due probably to the flowers of wild parsnip. Very shortly before the trouble appeared Mr. Van Dresser had been mowing a large patch of wild parsnip which was in bloom. It was a hot day, so that he perspired profusely. He gathered bunches of the wild parsnip plants in his arms and carried them. This brought the plants in contact with his face. Both Mr. Van Dresser and the physician feel confident that the wild parsnip was the cause of the trouble. Another gentleman who had heard of this case told me that some years ago he lost a little girl with poisoning of a somewhat similar character, and it was attributed to the parsnip blossoms, among which the little girl had been playing immediately before the attack." The roots are not poisonous.

203. Heracleum lanatum, Michx. Cow-Parsnip.

Supposedly poisonous, although the leaves of the fresh plant are eaten by the Indians. The species is widely distributed in the state, especially in rich woods. Contains the bitter principle *heraclin* $C_{32}H_{22}O_{10}$.

204. Daucus carota, L. Carrot.

The carrot, like the parsnip, causes vesication. Dr. Schaffner says that persons handling the plant are often poisoned, especially when the plant is wet with dew.

CORNACEAE.

205. Cornus paniculata, L'Her. Dogwood.

Widely distributed in the state.

206. Cornus candidissima, Marsh.

The fruits of this species are considered by some people to be poisonous, but there are no authentic cases.

Metachlamydeae (Sympetalae).

ERICALES. ERICACEAE.

207. Epigaea repens, L. Trailing Arbutus.

Reported from a limited area in Northeastern Iowa. Supposed to be poisonous. Contains the glucoside *ericolin* $C_{31}H_{56}O_{21}$.

PRIMULALES. PRIMULACEAE.

208. Anagallis arvensis, L. Poor Man's or Shepherd's Weather Grass.

Possibly growing in the state. Known to be poisonous. Contains the glucoside *cyclamin* $C_{20}H_{34}O_{10}$.

CONTORTAE. OLEACEAE.

209. Ligustrum vulgare, L. Privet.

The privet is occasionally cultivated in the state, especially in Southern Iowa. The leaves and fruit of the plant are said to be poisonous. Prof. Chesnut says that accidents have been occasioned in children, both by fruit and the leaves. Contains the bitter principle *syringopicrin* $C_{26}H_{24}O_{17}$.

MENYANTHACEAE.

210. Menyanthes trifoliata, L. Buckbean.

The plant has bitter properties and is nauseous. Contains *menyanthin* $C_{30}H_{46}O_{14}$.

APOCYNACEAE.

211. Apocynum androsaemifolium, L. Spreading Dogbane.

Widely distributed in the state, probably poisonous.

212. Apocynum cannabinum, L. Indian Hemp.

Like the preceding. Contains *apocynin,* which is poisonous.

213. Nereum oleander, L. Common Oleander.

Cultivated. The leaves, stems and flowers are poisonous. The honey from the oleander flower is poisonous. The leaves are deadly poisonous to stock. Contains *conessine* $C_{12}H_{20}N$, *neriin,* which has the properties of digitalein, nerianthin bears a resemblance to digitalin.

ASCLEPIADACEAE.

214. Asclepias tuberosa, L. Pleurisy-Root.

Widely distributed in the state, especially on gravelly knolls and prairies. The leaves are more or less poisonous to stock. However, honey bees collect considerable honey from this plant.

215. Asclepias incarnata, L. Swamp Milkweed.

Poisonous, probably, like the preceding. The root is emetic and cathartic.

216. Asclepias syriaca, L. Milkweed.

Poisonous. Contains the glucoside *asclepione,* an amorphous bitter substance.

217. Asclepias speciosa, Torr. Showy Milkweed.

Poisonous. This species is found in Western and Northwestern Iowa.

TUBIFLORAE. CONVOLVULACEAE.

218. Ipomoea pandurata, Meyer. Wild Potato Vine. Man of the Earth.

The large root is poisonous. Contains the glucoside *ipomoein* $C_{18}D_{132}O_{86}$.

219. Convolvulus sepium, L. Hedge Bindweed.

The plant produces a somewhat disagreeable odor. Dr. Schaffner states that it is supposedly poisonous to swine. Jalap contains several glucosides. The same probably occur in our Morning Glory. One is *convolvulin*, $C_{31}H_{50}O_{16}$.

BORRAGINACEAE.

220. Cynoglossum officinale, L. Hound's-Tongue.

Probably poisonous.

221. Cynoglossum virginicum, L. Wild Comfrey.

Supposed to be poisonous.

222. Lappula officinalis, Lehm. Stickweed.

The fruit of this plant gets into the wool and sometimes produces mechanical injuries.

223. Echium vulgare, L. Viper's Bugloss.

Occasionally spontaneous, probably in the Eastern part of the state.

LABIATAE.

224. Nepeta glechoma, Benth. Ground Ivy.

Widely naturalized in the state. Is said to be poisonous to horses.

225. Hedeoma pulegioides, Pers. Pennyroyal.

Common, especially in clay soils in Eastern Iowa. The oil is known to cause poisoning.

226. Leonurus cardiaca, L. Common Motherwort.

Known to produce mechanical injuries and dermatitis. Widely distributed in this state, naturalized in Europe.

SOLANACEAE.

227. Nicandra physaloides, Gaertn. Apple of Peru.

Cultivated here and there in the state. Said to be poisonous. Used as fly poison in parts of the United States.

228. Solanum nigrum, L. Black Nightshade.

The leaves and other parts of the plant are reputed to be poisonous to calves, sheep, goats, swine, and the green berries are known to be poisonous to man. The fruit of a form of this species is cultivated as an esculent. The writer has not only eaten berries of this, but has seen others eat berries of this and the common Black Nightshade. Contains the alkaloid *solanine* $C_{42}H_{75}NO_{15}$, with a hot, bitter taste.

229. Solanum tuberosum, L. Potato.

At certain times the tubers of the potato are poisonous, especially when green. The writer knows of an instance where the eating of potatoes acted as a poison. The substances produced in the young shoots of the potatoes are *solanine* and *solanidine* $C_{40}H_{61}NO_2$.

230. Solanum carolinense, L. Horse-nettle.

Naturalized in Southern part of the state, and more or less widely distributed in Eastern Iowa. The fruit has a very disagreeable odor, and the plant as well as the fruit is narcotic.

231. Solanum dulcamara, L. Bittersweet.

The berries are poisonous, as are also the leaves. Cattle are known to have been poisoned by it. The bitter substance contained in it is known as *dulcamarin.*

232. Nicotiana tabacum, L. Tobacco.

Cultivated in different parts of the state, but not extensively. Narcotic and poisonous, and produces the alkaloid nicotine $C_{10}H_{14}N_2$, a very poisonous substance.

233. Nicotiana alatum, Link & Otto. Flowering Tobacco.

Poisonous like the preceding.

234. Hyoscyamus niger, L. Black Henbane.

Probably occasionally found in the state. Known to be poisonous to stock and also to hogs. Universally recognized as a poisonous plant in Europe and this country.. Probably one of the most deadly poisonous plants in the United States. Seeds are poisonous to chickens. Contains the alkaloid *hyoscyamine* $C_{17}H_{23}NO_3$.

235. Datura stramonium, L. Jimson-weed.

Naturalized in various parts of the state. All parts of the plant are narcotic and poisonous, especially the seed. Several cases of poisoning in children are reported in the state. The plant produces a very disagreeable odor, and the hay containing the plant is poisonous to cattle. It contains the alkaloid *atropine* $C_{17}H_{23}NO_3$, *hyoscyamine,* and *stramonine.*

236. Datura tatula, L. Purple Jimspon-weed.

Poisonous, like the preceding, and the following species. Naturalized in different parts of the state.

237. Datura wrightii, DC. Wright's Datura.

Frequently cultivated as an ornamental plant, is known to be poisonous. The nectar from the flower which is produced in great abundance is known to produce poisoning to children in this state.

238. Capsicum annuum, L. Red or Cayenne Peppers.

Well known remedy used as a stimulating plaster externally, if the pepper is applied long enough it produces vesicles. Red pepper is often injurious when taken in too large doses internally. The active poison is *capsicol* $C_9H_{14}NO_2$, with a strong odor and burning taste.

239. Verbascum thapsus, L. Common Mullein.

Widely distributed in this state, occurring in rather dry, sterile soil, a weed introduced from Europe. This species is said to produce dermatitis.

240. Scrophularia marylandica, Gray. Simpson Honey Plant.

Widely distributed in the state, pastures and woods. Not eaten by stock. According to Millspaugh, the physiological effect of this plant is bleeding of the gums, colic, and sleepiness. Contains a crystalline bitter substance, *scrophularin.*

241. Digitalis purpurea, L. Purple Foxglove.

This plant is widely cultivated in the state and is poisonous to man and

live stock, especially horses. It contains the glucoside *digitalin* $C_{40}H_{78}O_{30}$ which dilates the pupil. *Digitoxin, digitonin* $C_{31}H_{52}O_{17}$. *Digitalein.*

242. Gerardia tenuifolia, Vahl. Slender Gerardia.

Said to be poisonous to sheep and calves. Probably other species are likewise poisonous, like *G. grandiflora* and *G. purpurea.*

243. Pedicularis lanceolata, Mx. Lousewort.

Widely distributed in low grounds and swamps. Said to be poisonous.

244. Pedicularis canadensis, L. Lousewort.

Widely distributed in the state, gravelly soils and knolls. Said to be poisonous. Sheep, however, eat large quantities of the *P. groenlandica* without apparent injuries.

BIGNONIACEAE.

245. Catalpa speciosa, Warder. Hardy Catalpa.

Widely distributed in the state, odor coming from the fragrant flowers is poisonous and Dr. White in his Dermititis Venenata states that the flowers are irritating to many persons. Dr. Millspaugh, on the other hand, makes a statement that it is said to be dangerous to inhale the odor of the flowers for a long time, which, however, is probably not generally true. The allied Caroba contains the bitter principle *carobin.*

246. Catalpa bignonioides, Walt. Common Catalpa.

Occasionally cultivated in the state, but scarcely hardy. Poisonous like the preceding.

RUBIALES. RUBIACEAE.

247. Cephalanthus occidentalis, L. Buttonbush.

This plant commonly occurs in low grounds, especially along river courses. The leaves contain a poisonous principle. Contains cephalanthin $C_{22}H_{34}O_6$, a very bitter glucoside.

CAPRIFOLIACEAE.

248. Triosteum perfoliatum, L. Feverwort, Horse-gentian.

Widely distributed in woods. Some species of the genus were used by the Indians as a cure for fevers and early practitioners in this country used the root as an emetic. In the early days the berries of this plant were used as a substitute for coffee. The physiological action of the plant is to produce vomiting.

249. Sambucus canadensis, L. Elderberry.

Dr. Rusby states that the plant is poisonous. The elderberry is widely distributed in the state and the flowers of this are commonly used to prepare a tea.

250. Symphoricarpos vulgaris, Michx. Coral-berry.

Common in southern Iowa, occurring on sterile or rocky soils and on borders of woods.

CAMPANULATAE. CAMPANULACEAE.

251. Lobelia cardinalis, L. Cardinal-flower.

This is listed as one of the poisonous plants by Dr. Schaffner. Cardinal-flower is very abundant in the swamps along river courses in Eastern Iowa, *less common in* Central Iowa.

?. Lobelia syphilitica, L. Blue Lobelia.

so listed as a poisonous plant by Dr. Schaffner.

. Lobelia spicata, Lam. Pale Spiked Lobelia.

erywhere on prairies throughout the state. Probably poisonous like the ling.

l. Lobelia inflata, L. Indian Tobacco.

dely distributed, occurring in woods. The leaves of this plant were used e Indians. The plant has long been used in medicine. *Lobelia inflata* y poisonous, used for its action upon the pneumogastric nerve and the doses produce exhaustion, dilation of the pupils. Death is usually pre- by insensibility and convulsions. Contains the acrid *lobeliine.*

. Lobelia kalmii, L. Kalm's Lobelia.

und only in swamps in northern Iowa. Probably poisonous like the ling.

MPOSITAE.

i. Cichorium intybus, L. Chicory.

s become widely naturalized in parts of the state. When fed in large ities to dairy cattle it imparts a bitter flavor to the milk and butter. itter glucoside *chicorin* $C_{32}H_{34}O_{19}+4\frac{1}{2}H_2O$.

'. Ambrosia artemisiaefolia, L. Common Ragweed.

: pollen of this plant is suspected of causing hay-fever.

;. Ambrosia trifida, L. Great Ragweed.

e pollen of this species is said to produce an irritating action upon the ıs membrane.

. Xanthium canadense, Mill. Cocklebur.

ung seedlings of this plant are poisonous to horses. Several cases of ıing to hogs have been reported in this state.

). Xanthium strumarium, L. Cocklebur.

sonous like the preceding. This species is not common in the state. ins the glucoside *xanthostrumarin.*

.. Eupatorium perfoliatum, L. Boneset.

mmonly found in low grounds and marshes. Emetic in large doses.

?. Eupatorium ageratoides, L. White Snake-root.

dely distributed in woods in this state. It is said to produce a disease ı as milk fever. No reports of this kind of poisoning have come to the :s in this state. The *E. cannabinum* contains the alkaloid *eupatorine* $O_{36}HNO_3$ and the glucoside *eupatorin.*

}. Erigeron canadensis, L. Horse Weed.

dely distributed troublesome weed in the state. The physiological action e drug obtained from this plant is to produce smarting of the eyes, ess of the throat, and prostration.

l. Solidago canadensis, L. Golden-rod.

dely distributed in the state, one of the most common of our golden-rods. ;olden-rods are generally regarded as harmless plants, but in a few cases are suspected of being poisonous. A disease of horses near Black River Wisconsin, was attributed to a golden-rod. Chesnut thinks the disease o a rust on the plant. As a general thing stock does not relish the ı-rod.

265. Rudbeckia laciniata, L. Cone-flower.

In moist grounds throughout the state. Dr. Schaffner says it is supposed to be poisonous to sheep.

266. Bidens frondosa, L. Black Beggar-ticks.

Common in the state. The downwardly barbed awns are irritating.

267. Coreopsis discoidea, T. & G. Small Beggar-ticks.

Very common in the state. Is a local irritant.

268. Helenium autumnale, L. Sneezeweed.

Common in low grounds throughout the state. Used by the Indians to produce sneezing. The whole plant and flowers are poisonous to cattle and sheep.

269. Achillea millefolium, L. Yarrow.

Used as a forage plant, but it causes an irritating sensation of the membranes and much pain in the gastric and abdominal regions. It contains the glucoside *achillein* $C_2H_{38}N_2O_{15}$, an amorphous bitter substance, the alkaloid moschatine $C_{21}H_{27}NO_7$.

270. Anthemis cotula, L. Mayweed.

Has a very disagreeable odor, causes blistering of the skin. The plant is carefully avoided by stock.

271. Dysodia chrysanthemoides, Lag. Fetid Marigold.

Common in the western part of the state. The leaf bracts and other parts of the plant are provided with large pellucid glands which produce the characteristic odor of the plant.

272. Tanacetum vulgare, L. Common Tansy.

Introduced into many parts of the state. Many serious and a few fatal cases of poisoning are recorded by the use of tansy oil. The symptoms of poisoning are varied, convulsions, violent spasms, dilation of the pupils, frequent and feeble pulse. Eleven drachms of the oil in a girl produced death in three and one-half hours. The effect on animals is salivation, vomiting, dilation of the pupils, muscular twitchings, followed by chronic spasms, death appears to be caused by paralysis of the heart and lungs.

273. Artemisia biennis, Willd. Biennial Wormwood.

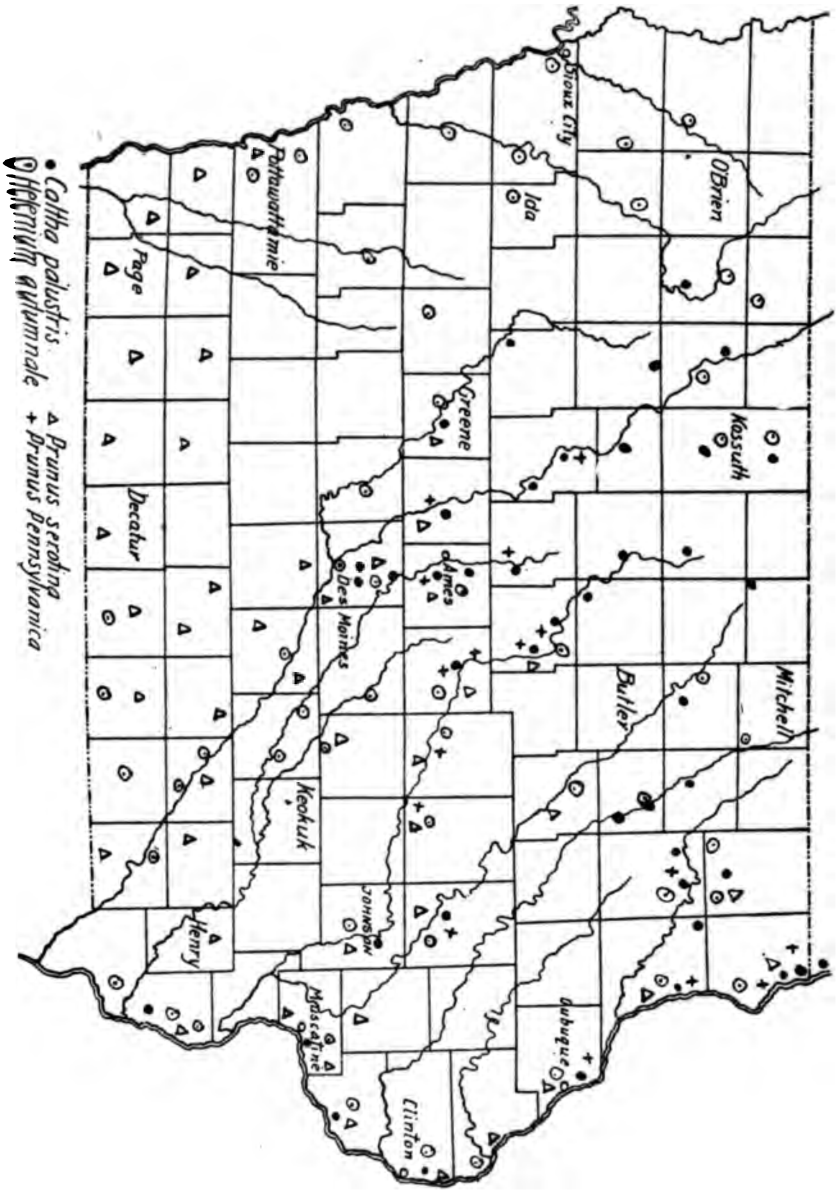
Probably poisonous.

274. Artemisia absinthium, L. Common Wormwood.

Occasionally cultivated. The volatile oil of the plant is a violent, narcotic poison. Contains the glucoside *absynthiin* $C_{15}H_{20}O_4$, the alkaloid *abrotine* $C_{21}H_{22}N_2O_2$, the bitter principle *santonin* $C_{15}H_{18}O_3$.

275. Arctium lappa, L. Burdock.

Produces itching. Contains the alkaloid lappine. Common weed in the state.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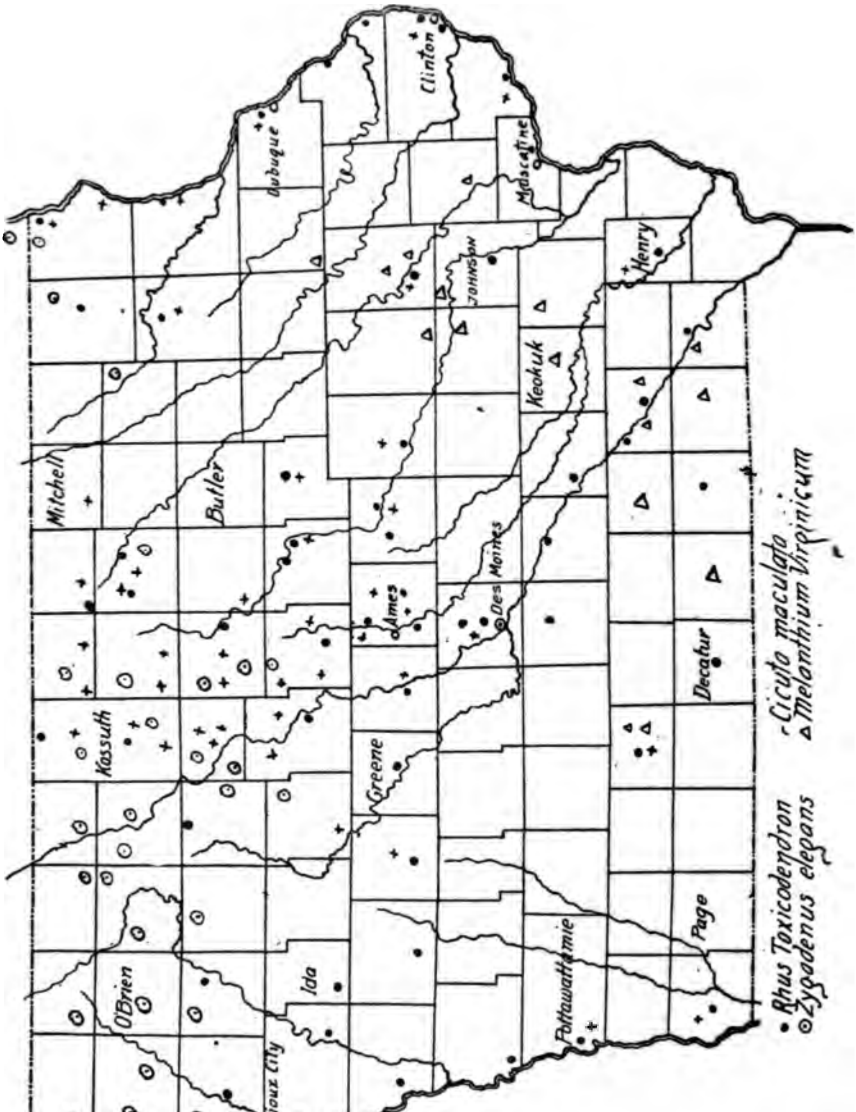
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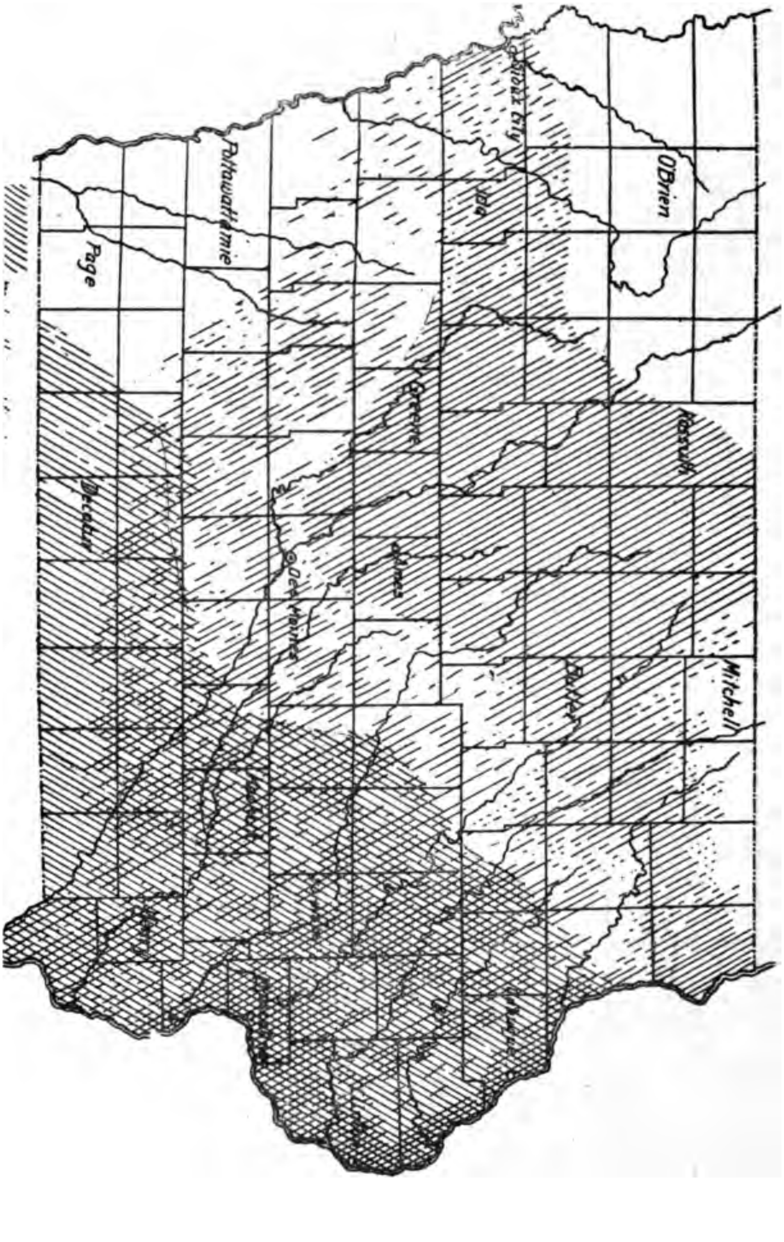
Pottawattamie
• Rhus Toxicodendron
⊙ Zygadenus elegans
+ Cicuta maculata
Δ Melanthium Virginicum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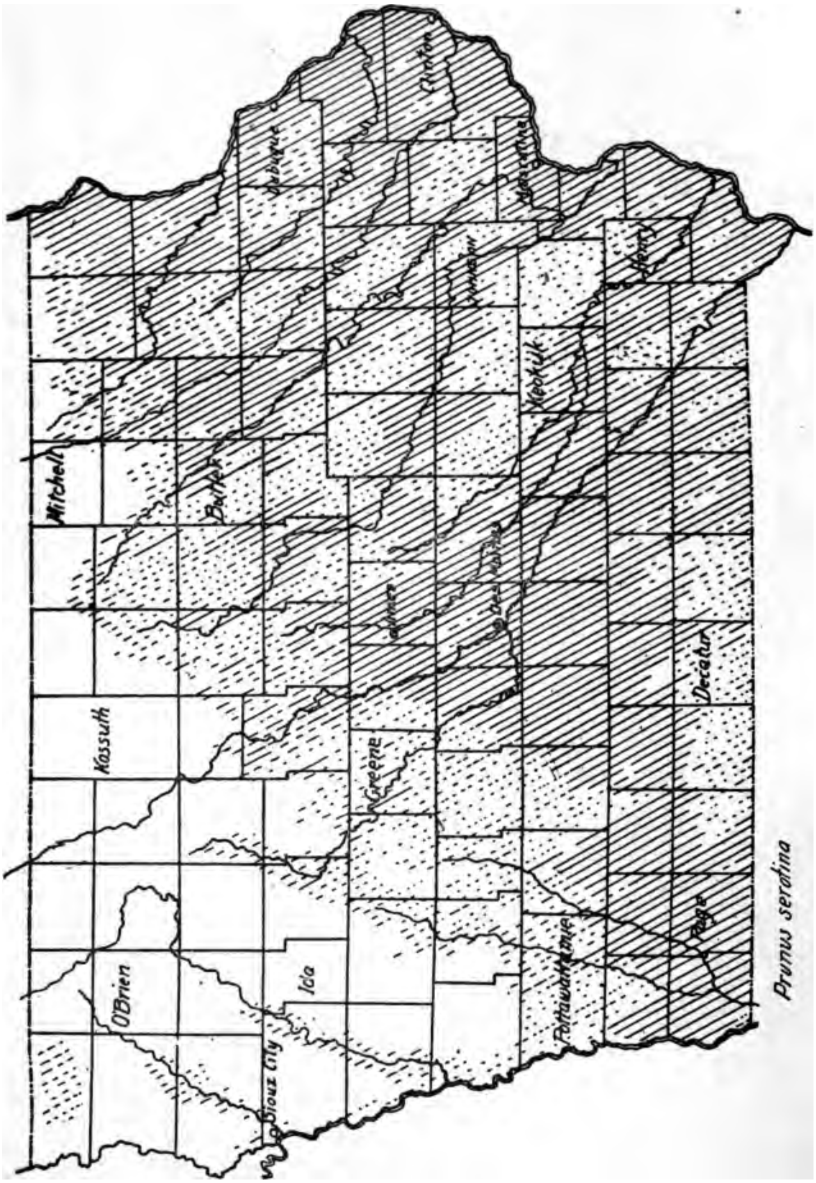

Prunus serotina

ECURING A STAND OF CLOVER ON THE SOUTHERN IOWA LOESS.

BY E. B. WATSON.

At the Sub-station at Leon, Decatur County, conducted by the oil Section of the Iowa Experiment Station, clover was sown on 1e series of oat plots in the spring of 1905, some of the plots being :eated with stable manure. It was noted during the season that 1e manured plots had the best stand, and much the best growth of lover. This is not a new discovery, but the cause seems to be a 1atter of speculation and conjecture. Clover is an important crop 1 Iowa, and is especially needed in that part of the State to supply ost humus and restore productiveness. Furthermore, it is often ery difficult to get a good stand there especially on the points and 'ay hillsides.

In view of these facts it was decided to make a thorough study the influences governing the germination and early growth of over on the soil found there, including the action of manure on e clover.

The following is the report of the bacteriological work underken in connection with this study:

THE BACTERIOLOGICAL QUESTION.

A recent editorial in *Wallaces' Farmer* headed "What Barnyard anure Does for the Soil" has the following statement: "The ain value of manure does not lie in what is known as its fertilizing ements. What else does manure do to the soil? First, it inocutes the soil with bacteria, and soil that is full of bacteria is a soil good physical condition—a productive soil." This very well xpresses the general belief in regard to the bacteria brought by the ianure. Bacterial life is very active and abundant in the manure, nd it is but natural to suppose that these bacteria when added to 1e soil have a great deal to do with its added fertility. When this 'ork was first started, it seemed altogether likely that an investiation of the causes of the benefit derived from barnyard manure, 'ould lead into a bacteriological study.

In the first series run, pots treated with sterilized manure were n along with the regular manured pots. The manure was sterzed by heating in the autoclave for thirty minutes at 120°C.

This eliminated all bacteria, both the special clover bacteria and the numerous fermentations and decomposition bacteria.

Following are the green weights taken May 3d, one hundred and twenty-four days after planting:

Pot	Treatment	Wt. Crop g.	Average	No. of Plants	Wt. per Plant g.	Average
40	Horse Man.	38.9	....	17	2.29	....
41	Cattle Man.	53.3	....	30	1.71	....
42	Mixed I	45.4	47.	15	3.03	2.35
43	Mixed II	50.2	....	21	2.39	....
44	0	7.2	7.2	6	1.20	1.20
45	Horse M. Ster.	54.6	....	15	3.64	....
46	Cattle M. Ster.	51.7	45.	36	1.44	4.31
47	Mixed I. Ster.	34.2	....	6	5.70	....
48	Mixed II. Ster.	38.9	....	6	6.48	....

The stand varies so much that it is hard to make exact comparison, but surely the sterilized manure suffers nothing by the comparison, however we look at it. No. 40, horse manure, and No. 45, the same sterilized, have the same stand practically, but the sterilized pot has 40% heavier crop. The average of the four unsterilized pots is 47 grams per pot, and the sterilized pots 45 grams. Surely very close together. We see though that the unsterilized pots had much the heavier stand and when comparison is made on the weight per plant, the sterilized pots are very far ahead, 80% better in fact. However, where the stand was thinner the plants would have a much better chance to develop, so a comparison on this basis is not altogether fair. But taking everything into consideration, we feel safe in saying that sterilization has not lessened the benefit to be derived from the manure. In fact it really seems to have helped it.

In a later series this question was tested again. 71 was a check pot, 73 had cattle manure added and 74 had the same sterilized. They were planted February 24th. April 14th a study of the pots showed that manure had a decidedly beneficial effect, but no difference was noted between the sterilized and unsterilized pots.

There is a decided benefit from the use of stable manure and sterilizing it does not seem to decrease this effect.

Notes were taken at this time and again May 24th. Final green weights were obtained June 1st. The following table gives all these data. The pots are compared with each other by rating the check pot 100 and giving the relative standing of the others:

No.	Treatment	Relative Growth May 3d.	Relative Growth May 24th	June 1st—Green Weight		
				Weight	No. Plants	Relative Weight
71	0	100	100	17.15	13	100
73	Manure	300	240	43.3	13	252
74	Sterilized Manure	275	240	40.4	13	240

These figures show that the sterilized pot was practically as good 3 the unsterilized, the slight difference being within the limits of 'ror.

These two tests, or rather five tests, for there were five pair of 'ts tried, settle beyond dispute the question of the influence of the .cteria brought by the manure. The bacteria in the manure have 'thing to do with the growth of the clover, for the clover grows st as well without them. This also settles the question of inocula- ›n with the especial clover nodule bacteria. It has been stated ıny times that manure was one of the ways of inoculating alfalfa clover. This shows that such inoculation is not necessary. ırther than that, care was taken to ascertain if the clover was ɔculated on the field plots. It was found that all the clover plants the untreated plots were inoculated. Also the poor, stunted ınts in pot 37, a check pot, were pulled up March 14th and were ınd to be well inoculated with tubercles on their roots. This soil ıs undoubtedly inoculated with the clover nodule bacteria, and ilure to produce good stand and growth had nothing to do with is bacteria.

But what about the other bacteria that the manure contains? ıe following in an extract from a short article by Joseph E. Wing, at prince among agricultural writers, in the *Breeder's Gazette* June 13, 1906: "If I could use horse manure made by horses ɘding on alfalfa hay, I would snap my fingers at purveyors of com- ɘrcial cultures. And I guess that any sort of manure whatsoever ıen incorporated with the soil will put in the yeast that will start e ferment that we call nitrification and that bacteria will be found ere (how they will get there we can only guess) and that alfalfa ll thrive if only the land has lime enough in it to make it sweet, ıd is not wet."

Here is also an extract from an article by Dr. Chas. D. Wood,[1] irector of the Experiment Station at Orono, Maine, on "Nitrogen Relation to Soil Fertility": "The application of farm manure

1. Agriculture of Mass. 1905, page 185.

is advantageous from two wholly different reasons. They carry considerable quantities of plant food, particularly nitrogen. This is the chemical side which has been in the past perhaps unduly emphasized. There is another equal and in some cases greater advantage derived from the application of farm manures, because of the large amount of nitrifying bacteria which they carry to the soil."

This opinion expressed by the scientist agrees with that expressed by the practical man, and they both voice the general idea in regard to the function of the bacteria in the manure. But here we find a mistake has been made. There may be numerous bacteria in the manure but they have nothing to do with the growth of the clover. When they are taken away the clover grows just as well.

But this by no means settles the bacteriological question. A count of the number of bacteria was made on March 17, 1906, or 77 days after the loess pots were treated and planted, and 73 days after the till pot was planted. The media used for the first count was gelatine of rather poor quality and much liquefaction took place and the count was uncertain. A few days later another count was made using agar, and this proved entirely satisfactory. The results of both counts are given in the following table:

Pot	Soil	Treatment	Gelatine Media		Agar Media	
			Bac. per. g.	Molds per g.	Bac. per g.	Molds per g.
44	Loess........	Check	100,000	15,000	1,000,000	32,000
41	Loess........	Manure	2,400,000	3,000,000	4,000,000	240,000
46	Loess........	Man. Ster.....	7,500,000	150,000	14,000,000	300,000
65	Till...........	Check........	1,300,000	200,000	700,000	70,000

As was expected, the second count gave larger numbers but they should be depended upon rather than the first figures. It is seen that there are a great many more bacteria in the soil that had been treated with the manure than in the untreated soil. This means that the manure made a good medium for growth of the bacteria. It is also true that clover grows a great deal better on the manured soil, and the question now is, what connection, if any, do these two facts have with each other.

The sterile manure as soon as it touched the soil was inoculated. The untreated soil was low in bacterial life, not because it lacked *inoculation, for* all kinds of bacteria were there, but because the

conditions for growth were not favorable. As soon as the manure was added they multiplied because there were food and favorable conditions. Scientific researchers have demonstrated that bacteria have a great deal to do with preparing food for the higher plants. They produce decay of the organic matter in the soil. The carbon after numerous steps finally is changed to carbon dioxid, the protein nitrogen finally takes the form of ammonia, nitric acid or free nitrogen. The higher plants obtain their nitrogen from nitrates, their carbon from carbon dioxid and even the mineral elements owe their availability largely to bacterial action.

"The[1] greater part of the bases are taken up as nitrates and phosphates, and also as salts of the organic acids. Phosphoric acid exists in the soil in the form of insoluble basic phosphates, which under the action of organic acids are converted into neutral or acid salts which are soluble. Hence the production of organic acids by bacterial fermentation renders phosphoric acid available to plant roots. Carbonates unite with silica to form zeolites and these in turn are slowly decomposed by organic acids and their contained bases again liberated as organic salts. Thus by the combined production of carbonic, nitric and the various organic acids, through the action of bacterial life, we have all the necessary agencies at hand for the dissolution of the mineral elements of plant growth."

F. Dafert[2] and Kornauth, Vienna, Austria, report experiments with oats inoculated with alinit, *Bacillus megatherium*, *B. subtilis*, etc. The yield averaged 62.5 g. for the check which received a complete fertilizer, 66.2 g. where inoculated with alinit, 66.5 g. where inoculated with *B. megatherium* and 76 g. where inoculated with *B. subtilis*.

We see that bacteria may play a prominent part in soil fertility, and the question is how much did they do in the case of the clover?

It may be that the manure by supplying food for the bacteria, or correcting the reaction of the soil, has produced a growth of bacteria which is favorable to the growth of the clover. There are undoubtedly more bacteria there in the soil. It may be that these have worked upon the plant food in the soil or the manure, and by this action made it more available for the clover. In the long run, bacteria undoubtedly do have much to do in the preparation of plant food and it would seem that in the case cited above that *Bacillus subtilis* helped the growth of the oats about 20%. If they are responsible for the better growth of the clover, it would seem that the clover would suffer if they were removed.

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1 F. D. Chester, Penn. Dept. Agriculture. Bul. 98.
2 Experiment Station Record 16, p. 851.

The following experiment was planned to secure data on point. Soil from plot 113 of the Leon station was used:

Pot 161 and 162 check.
Pot 163 and 164 manured.
Pot 165 and 166 sterilized.
Pot 167–168 manured and sterilized.

Manure leachings were used for treatment. 3 inch flower were used because four of them would go under the available jars. 165-166-167-168 after being filled were wrapped in pa and put in the autoclave and kept for 45 minutes at 10 pou pressure. 4 Petri dishes were also sterilized. These were for pots to set in. The inside of the bell jar was washed out wit saturated solution of mercuric chloride and a glass plate was washed off with this disinfectant. Red clover seed was put a small E flask and washed with a saturated solution of merc chloride and then well rinsed with sterile water three times. Al fifteen of these sterile seeds were planted in each pot by mean a flamed forceps. The surface was scratched and the seeds ered about one-fourth inch deep. The pots were watered sterile water and the four sterilized pots covered with a large jar, and the four unsterilized pots covered with another bell so that conditions would be parallel. The planting was done O ber 23d. By November 7th it was seen that sterilization was complete, for the four pots which were supposed to be sterile mold on the surface and the plants were looking sickly. The cl on the unsterilized pots was looking fairly well, but growing slender. By November 27th the clover on the sterilized pots all dead, evidently killed by the mold. On the unsterilized pots clover had made a fair growth. A count of the bacteria and m on the sterilized pots was made at this time by inoculating s agar plates by the usual method. The idea was simply to se the soil was sterile, and not to know just how many bacteria molds were present.

data was as follows:

Pot	Dilution	Bacteria	Molds
165.	1-10.......	Many	
165.	1-100......	Many	
166.	1-10.......	....	Many
166.	1-100......	....	Few
167.	1-10.......	....	Many
167.	1-100......	Few.......	Many
168.	1-10.......	....	Many
168.	1-100......	Few.......	Many

.s shows that none of the pots were sterile but that the molds more numerous than the bacteria. There was apparently only pecies of bacteria but three kinds of mold.

ese pots were sterilized over again leaving them a longer time e autoclave. The seeds were sterilized by leaving them 2½ ; in the corrosive sublimate solution. Planted November This time the clover on the unsterilized pots was attacked killed by mold while the plants on the sterilized pots grew er and sickly and finally died. Thus nothing was learned from two experiments except that clover was a difficult crop to under these conditions.

clover was found to be so unsuitable, it was decided to try t, as the probabilities are that the relation between wheat he bacteria is very nearly the same as that between clover and ria.

e same soil was used. The series was as follows:

Pot 401 and 402 checks.
Pot 403 and 404 leachings of manure.
Pot 405 and 406 sterilized.
Pot 407 and 408 leachings added and sterilized.

e wheat for the seeding was sterilized with corrosive sub- e for two hours, and then washed several times with sterile '. The pots with the soil in them were sterilized in the auto- for one hour at 10 to 15 pounds pressure. 4 inch pots were and one was put under each bell jar. 5 seeds were planted ch pot one-fourth inch deep on January 11, 1907. None of wheat sprouted, evidently being killed by the corrosive sub- e.

e series was planted again February 4th. The soil was re- ized, and the seeds kept only twenty minutes in the saturated on of corrosive sublimate. Only one seed in this series grew.

February 16th the wheat series was replanted for the third t The soil was not resterilized. The seed was sterilized by immer for ten minutes in 5% formalin and then rinsed in sterile w This time the seed grew, or enough of them grew so that a c parison could be made. All pots both sterilized and unsteril were covered with bell jars so that conditions would be ident All plants grew well up till the first of March, when 406, the s ilized check began to fail. In a few days 405, its duplicate be to show signs of dying. By March 6th, 406 was turned decid yellow and the tips of the leaves were dried up.

On March 8th a sample was taken from each pot to deter the number of bacteria in each. Each sample was secured by ing a small amount on the end of a flamed spatula from three ferent places just below the surface on each pot. This was pl in sterile Petri dishes, thoroughly mixed and about one-fo gram taken from each and placed in sterile test tubes for dilu Two agar plates were poured from each with dilutions of 100 1,000 respectively. No effort was made to get exact numbers, the notes made were as follows:

401. Many bacteria, many species, colonies all sizes, one mold.
402. Many bacteria, many species, colonies all sizes, one mold.
403. Ten times as many bacteria as 401, colonies the same, twenty molds.
404. Twenty times as many bacteria as 401, colonies the same, twenty mol
405. Many bacteria, colonies mostly very small. Few large ones.
406. One-tenth as many bacteria as 401, colonies mostly very small.
407. Bacteria very numerous, colonies all quite small.
408. Bacteria very numerous, colonies all quite small.

It is seen that none of the pots were sterile, but it is plainly that the character of the flora has been changed by the steriliza It would seem that one species which has the characteristic of fo ing very small colonies on agar plates survived the sterilizatio all four pots and that in addition, pots 405 and 406 became l inoculated with other bacteria. There were no molds on sterilized pots. On March 9th the poorest one of each of duplicates was harvested and the data is here given:

Pot	No. of Plants	Green Wt. g.	Wt. per Plant	Relative Weight
401	2	.240	.120	100
404	3	1.265	.422	351
406	3	.445	.148	123
408	3	1.275	.425	354

It is here seen that sterilization helped the growth of the wheat on the untreated soils, and did not hinder it any on the manured soil. The plants on all the pots were thrifty, except 406. The plants on it were nearly dead.

The cause of the trouble with the wheat on pots 405 and 406, the untreated sterilized pots, was given consideration. It was thought that it might be due to lack of nitrates in these pots; as nitrification could not go on in a sterile soil, possibly the nitrates were all used up and the plants were consequently dying. To test this hypothesis the following experiment was planned: The pots from which the plants had just been cut, were elevated on a ring stand, distilled water was applied to the surface until it percolated through, this dropped on to a filter and from this was caught in a graduate. This filtrate was tested for nitrates with the brown ring test. The percolates from all the pots showed the presence of nitrates very decidedly. The percolate from 406 was tested the second time and each time it gave a distinct test for nitrate. Pot 408 gave a very strong test for nitrates. So it is evident that the plants in pot 406 were not dying for lack of nitrates.

March 16th the remaining pots were harvested and the data is given below. The plants on 403 and 407 were very thrifty, those on 402 were one-third dead and those on 405 were one-fourth dead, and the whole plant looking yellow and sickly.

Pot	Treatment	No. Plants	Green Wt. g.	Wt. per Plant g.	Relative Weight
402	0	2	.552	.276	100
403	Man.	4	2.988	.747	270
405	Ster.	5	1.600	.320	116
407	Man. Ster.	4	3.150	.787	285

It is seen here also that sterilization has helped the growth of the wheat, whether the soil is manured or not. The fact that sterilization was not complete, but only partial, destroys much of the force of this argument, but still it is felt that there was some sterilization and that some of the species of bacteria were eliminated and that this data has some value.

It was decided to test the reaction of the soil to see if the species which formed the small colonies, made the soil acid. To do this, soil extract was obtained as before, 100 cc. portions were placed in a beaker, brought to a boil to expel CO_2 and titrated with N-50 acid and alkali solutions, lacmoid being used as an indicator. None

of the pots were found acid, but all were slightly alkaline, as norm soils should be. So the cause of the dying of the plants on po 405 and 406 is unexplained. It was not due to acidity of the so and it seems that it could not be due to lack of plant food, for the were free nitrates present and the corresponding pots unsterilize showed no lack of plant food.

The following investigation[1] on the effect of soil sterilization o the development of plants bears directly on the point under di cussion. It was made by C. Schulze of Germany. He made p experiments with field, meadow and garden soil. The crops grow were oats, mustard, peas, buckwheat and grasses. One pot of eac series was untreated, one was sterilized for one hour at 125°C. be fore fertilizing, one sterilized the same after adding the fertilizer and a fourth was sterilized at 100°C. for 18 hours. During steriliza tion, there was found to be a formation of more or less injurio decomposition products and also a release of otherwise non-avail able nitrogen. The addition of lime counteracted the injurious ef fects of the decomposition products. In general sterilizatio seemed to retard growth for a time, but later the plants becam more vigorous in the sterilized pots, often exceeding in total growt those in the untreated pots. In most cases there was an increas in the total plant product which was attributed to sterilization.

This agrees exactly with my results and it seems safe to con- clude that the bacteria in the soil did not aid in the better growt of the clover. They may have, and in fact seem to have a great dea to do with elaboration of plant food and the probabilities are tha a soil kept sterile, would soon become unproductive, but it als seems true that the loss of the bacteria would not be felt the firs few months or during the production of the first crop. If that i the case, the greater number of the bacteria in the manured pots 41 and 46, noted above over the check No. 44, was due to the sam cause as the better clover, but the larger number of bacteria wer not responsible for the larger clover. That is the question we were working on. If this may be considered settled, then the con- clusion is that bacteria in no way were responsible for the bene- ficial action of the manure on the growth of the clover, for in the first place it was shown that sterile manure was as beneficial as the unsterilized, and in the second place it was shown that when the whole pot was sterilized, the crop did not suffer but was even a little better.

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1. Abst. Experiment Station Record 18, p 542.

SOME FEATURES OF IOWA GROUND WATERS.

BY W. S. HENDRIXSON.

About ten years ago the Iowa Geological Survey published an elaborate Report on Iowa Artesian Wells by Professor William H. Norton of Mt. Vernon. In this Report, which occupies most of Vol. VI of the Survey, are published the analyses of about fifty deep well waters. The geology of these wells and other deep borings was fully discussed, and illustrated.

About two years ago the United States Geological Survey extended its hydrographic work to this state. The Chief of the Department of Hydro-Economics, Mr. Marshall O. Leighton, visited the state and while here arranged with the writer for the further chemical examination of Iowa well waters, principally with regard to their fitness for economic uses. A year later a plan was made providing for the co-operation of the U. S. and Iowa Geological Surveys with a view to the preparation and publication of a more comprehensive statement of the geology and hydrography. The local work on the geology was to be in charge of Professor Norton and the chemistry of the water in charge of the writer. Last spring the scheme was still farther developed, and was extended to the important shallower wells, so as to make a more nearly complete statement of Iowa water resources. Professor Simpson of Colby College and three assistants were sent into the field to search out and investigate unrecorded or little known wells. During the summer they covered most of the state and collected a large amount of material, which will be used in the state and county reports.

The work in the state was taken up by the Department of Hydro-Economics and the object was primarily practical and economic. Later a combination in the work was effected with the Department of Geology with a view of covering the whole ground of the Iowa deep wells from both the practical and the scientific standpoint.

It is not the purpose of this paper to discuss the value of the work save at one point. Iowa is a state with a scanty supply of surface water, when compared with other states, especially our northern

neighbors, Wisconsin, Minnesota and Michigan, with their almost innumerable lakes and rivers of excellent and never-failing water. Probably Iowa has no lake or river water suitable for a municipal supply without treatment. The lakes are on the northern border of the state away from important centers of population. The important rivers that may be relied upon to supply large amounts of water, such as it is, are the Mississippi, the Missouri, the Des Moines and the Cedar. Apparently, it must always be that a very large proportion of the Iowa cities and towns must depend upon drilled wells for their water supplies, or at any rate upon wells of some sort; that is upon ground waters. Now the drilling of deep wells is very expensive. Well number 3 at Grinnell, cased and ready for the machinery for pumping, cost $8,000. Before city officers or even the isolated farmer in need of a better supply of water enters upon such an expensive and it may be, fruitless operation, he wants to know the probabilities, at least, that his efforts and outlay will be rewarded. To determine that matter is too large an undertaking for the individual or even the city. The government takes up the problem and by the correlation of data at hand and collectible it is able to chart the water probabilities of a distrct or a state, so that any individual or corporation may know in advance what to expect from a drilling,—how deep he will have to drill to get the desired supply of water, and what its quality will most probably be.

The analytical work on Iowa well waters during the past two years has been done in the chemical laboratory of Iowa College, mainly by the writer. There were shipped to this laboratory about thirty samples of water from Minnesota deep wells. To make the analyses of these waters and also to assist in the Iowa work as might be necessary, Mr. H. S. Spaulding of the national Survey was sent to Grinnell and remained about three months. About twenty-five analyses of Iowa waters are to be credited to him.

The waters that have been chemically investigated have been those of wells 500 feet deep or more; also, from wells as shallow as 100 feet when they supplied towns or represented large and important water-bearing sand areas. In general only a sufficient number of well waters from any given locality has been analyzed to determine with certainty the water bearing capabilities of the strata penetrated. In some cases spring waters have been investigated when the flows were large and when the waters were used or likely to serve important economic or other interests.

As a rule only mineral analyses have been made, though where evidence pointed to large amounts of nitrate this has also been determined. The usual determinations have been,—Cl, SO_4, HCO_3, SiO_2, Fe, Al, Ca, Mg, Na and K. Up to the present time the total number of analyses is about three hundred. About fifty have been transcribed and recalculated from Professor Norton's Report, a large number have been collected from the railroads and from other sources, but the larger portion have been made at Grinnell. The railroads to which the Survey is chiefly indebted are the Chicago & North-Western, the Chicago, Milwaukee & St. Paul and the Rock Island.

All the analyses obtained from railroads and other sources have been calculated into modern terms used by the Geological Survey. The old system of grains per gallon and hypothetical compounds has been discarded and all results save SiO_2 are expressed in ions and parts per million as they probably exist in solution. When waters are acid to phenoltalein the carbonic acid ion is assumed to be HCO_3, or, all carbonates are regarded as acid carbonates.

At the present time by no means all the general results from the data at hand have been worked out or even attempted. However, certain definite general statements can be made with reasonable confidence.

It may be stated as most of us were already aware that Iowa ground waters are, even at the best, highly mineralized. No water coming from below the drift has been analyzed by the writer, which contained less than 250 parts of solids per million. From this minimum we find all grades of mineralization up to about 10,000 parts per million. As a rule the heavily mineralized waters contain large amounts of the sulfates of calcium and magnesium, and sometimes of sodium. In some cases, as in the 1,000-foot well at McGregor, the largest constituent of the solid matter is sodium chloride, more than sixty per cent. of the solids of this water being sodium and chloride ions. As a rule, however, simple salt waters are not found in Iowa. The waters containing large amounts of salt are also charged with large quantities of calcium or sodium sulfate or both. So far as known to me there are, properly speaking, no magnesium sulfate waters. Almost invariably the amount of the calcium ion is at least twice that of the magnesium ion, and usually the proportion of calcium is much larger. In a few shallow wells sulfates are practically absent, and in a few of the best deep well waters, as at Vinton and Dubuque, SO_4 is all but absent, the

former of these waters, for example, containing less than 4 parts per million.

Except in two waters from shallow wells, both probably highly polluted, all Iowa waters examined have been found to be acid to phenoltalein; that is, they contain no normal carbonates. In many analyses by railroad chemists, however, considerable quantities of normal sodium carbonate are reported. In every case the waters analyzed have been found strongly alkaline to methyl-orange, which of course is not affected by carbonic acid. For these reasons, in practically all waters analyzed, the carbonates are regarded as acid carbonates and the acid ion is put down as HCO_3 when it is desired to represent the mineral matter as it actually exists in solution. Of course on evaporation approximately one-half of this ion is lost as CO_2 and H_2O.

There are in the state no highly carbonated waters such as those at Manitou and Saratoga. The ion HCO_2 rarely, if ever, exceeds 700 parts per million and usually falls rather below half of that amount. No waters have been found highly charged with free carbon dioxide, and 25 parts per million may be regarded as about the maximum. It should be stated, however, that in transit from the wells to the laboratory there is much opportunity for the loss of the dissolved gas.

When one attempts to formulate any general statements regarding the quality of deep well waters in different sections of the state and from different water-bearing strata, many complications are encountered. The difficulties are due to several causes which may be stated as follows:

1. There are not yet sufficient data available. For instance, in the southwestern section of the state very few deep wells have been drilled.

2. Except in the northeastern portion of the state deep wells receive water from more than one stratum, since the casings rarely go lower than about 1,000 feet.

3. Casings are difficult to make water-tight, and it is probable that in the majority of instances the casings have either been defective from the beginning or they have been rusted through by the highly mineralized waters of especially the carboniferous.

The problems of the relation of the quality of water to the geography and geology of the state have not yet been studied by the writer with any degree of thoroughness, and what is said below on this relationship is to be taken largely as tentative.

Whatever else may be uncertain, it is perfectly sure that the best waters obtained as yet from the deep wells have been obtained in the northeastern portion of the state. This section bounded on the west and south by a line from the Iowa lakes south to a little north of Des Moines, and then east to Muscatine, would contain all the deep wells which give abundant supplies of moderately good water. Outside of this area the deep well waters are scanty in amount or highly mineralized, and in fact, they are usually both.

It is certain also that the good waters from deep wells come from the lower sandstones. Downward or in the order in which they are penetrated by the drill they are, the St. Peter, the New Richmond, the Jordan and the Basal Sandstone. These strata outcrop to a small extent in the extreme northeastern corner of the state. In Wisconsin and Minnesota their surface areas serve as the collecting ground of water. These strata dip to the south and west and transmit through their porous structures the water which is to supply our wells in the northeastern portion of Iowa. As stated these strata outcrop or lie near the surface in the northeastern corner of the state. To the west they attain their greatest depth, along the northern border, at about the middle of the state then rise rather sharply to the west and apparently become obliterated as they near the northwestern corner of the state. In the northeastern portion of the state these rocks can be penetrated by drilling a few hundred feet and there is little or nothing to case out save the water from the drift. As we proceed to the south and west, however, these sandstones become deeply overlaid by the later geological formations, so deeply in fact that the effective shutting out of undesirable waters, especially from the carboniferous becomes more and more difficult and finally practically impossible. In this connection there is another consideration that merits attention. In the tabular statements of analytical results given below it may be observed that as we proceed to the south and west we find a sharp transition from comparatively soft waters to very hard waters. Now, if the statements of drillers and city officials are to be trusted there are some deep wells in the areas of hard waters that are cased to the bottom. It might reasonably be expected that some of them would have water only from the lower sandstones and that it would show as low mineral contents as the waters of the wells in Winneshiek County. In fact they never do. It seems, therefore, not impossible that there may be fissures sufficiently numerous and deep to allow a comparatively

free mingling of the waters of these sandstones with those of the upper layers. These questions, however, demand farther study than I have been able to give them before they can be settled.

Whatever may be the character of the unmixed waters from diffrent strata there can be no doubt about the actual quality of water obtained by the driller when he has penetrated the deep lying sandstones in different localities. In the following tables no absolute accuracy can be claimed regarding the identity of the lowest strata penetrated in some of the drillings, though in most cases there can be no reasonable doubt, according to Dr. Norton, from whose report they are mostly taken. They show the increasing mineralization from north to south, and from east to west.

Table one shows the increase in mineralization of deep well waters as we go west through the second tier of counties from the northern boundary, from Waukon to Hull. As may be seen there is practical constancy till we pass Emmetsburg, but at Sanborn and Hull the solids increase about five times.

Table (2) represents waters from wells in the fourth tier of counties south, beginning at Dubuque and ending at Sioux City. At Dubuque the large number of wells show about the same amount of solids and a fair average is taken. There is an apparent irregularity in the solids at Webster City, which may be explained from the fact that the water was taken from a gas drilling, which was probably never properly cased.

Table (3) shows wells in the sixth tier of counties beginning at Clinton. It will be observed that the results are in general the same as in tables (1) and (2), save that the transition from light to heavy waters occurs farther east. The varying amounts of solids in the Grinnell wells will be referred to later. South of the sixth tier of counties deep wells are few and afford no series from east to west.

If we change the direction and pass from north to south the same general results are obtained. Table (4) begins at Lansing and follows along or near the Mississippi river. The transition may be assumed to occur at Davenport since Wilton is at a considerable distance from the river.

Table (5) represents a chain of wells beginning at Calmar, extending south and slightly west to Centerville. The transition, which is less sharp, though this may be accidental, occurs at Amanaon, about the same parallel as Davenport.

Table (6) represents wells from Mason City on the north to Des *Moines. It is* probable that the Nevada well is too shallow to be

included in the series, but is the best available for the purpose.

In the southwestern portion of the state, the region outside the territory of the above tables, there are strictly speaking no deep wells save those at Council Bluffs and Glenwood, both of which furnish very hard waters.

The question is often asked whether the mineral content of a deep well changes with time and pumping. It would seem reasonable that the soluble mineral matter near the well might be dissolved out to a marked degree and that the water would in consequence gradually become softer. In the early stages of my work on Iowa waters this problem was taken up and several old wells were analyzed and these analyses compared with those contained in Professor Norton's Report. The effort in this direction was soon discontinued since it did not seem promising for several reasons. Some old analyses did not seem to be duly authenticated. Several wells had been deepened, partially filled, recased or abandoned, and in others the casings had very possibly become ineffective.

Most of the analyses made agreed fairly well with the old analyses, though my analyses showed the mineral matter usually somewhat smaller. This may have been due to more nearly complete dehydration of the residues obtained on evaporation. Further, there is reason to believe that new wells show higher solids before thorough pumping has removed the water in the immediate vicinity of the bore, and washed out the well. There are two striking exceptions to the general result. The older analysis from the well at West Liberty, carried out by Mr. Floyd Davis, shows twice the solids that I obtained; that is, 2,224 parts per million against my result, 1,066. In the water from the well at Nevada Mr. Briggs found 4,209 parts, while the recent analysis showed 2,368.

The uncertainty of such comparisons and the difficulty also of arriving at a true estimate of the quality of water in any deep lying stratum are well illustrated in the history of the deep drillings at Grinnell. Well number (1) is 2,002 feet deep and was drilled in 1893. In Professor Norton's report are the results of four analyses, made at different stages of the drilling, the last having been made at the end of the work. It shows 2,054 parts per million, and the other results are very nearly the same as this one. Considered as they stand there appears no great reason why the well should have been cased at all. As a matter of fact the casing was never effective.

Some years later well number 2 was drilled to the same depth. From the beginning of its use it was pumped more hours per day than well (1) and there was noticed a marked decrease in the hardness of the city water supply. From time to time determinations of the total solids in the city supply were made and they showed 900 to 1,000 parts. On February 25, 1905, a sample of water was taken from well (2) alone and showed the total solids 865 parts, while well number (1) showed on the same day 2,107 parts per million, which is practically the same as the waters from the Carboniferous at this point are known to contain. The writer drew the inference that the lower half of the well was filled up, and the practical test by running down an iron pipe showed that the well was not open below about 800 feet. All efforts to clean it and recase it proved unavailing and it was, therefore, abandoned and well number 3 begun. Small pieces of casing were removed from well (1) and they were full of rust holes. Well (3) is 2,020 feet deep and was completed about six months ago. Soon after the completion of this well difficulties were experienced in pumping well number (2). Shortly after repairs on it the total solids were determined and gave 3,207; and again, after hard pumping during four hours, a determination of February 4th showed 1,211 parts of solids per million. Well number (3) which was cased with much care showed soon after completion 1,578 parts of solids per million, and on April 25, 1907, 1,329 parts. From these records it seems certain that the strata at Grinnell and lying below 900 feet are capable under the most favorable conditions of supplying water containing as low as 865 parts of solids, and possibly if the upper waters were entirely excluded they might be found to give water with as small a content of solids as the same strata give in the northeastern part of the state. The records make it equally clear that practically an ideal deep well in this locality is difficult to construct, and to keep in perfect condition, and those who seek water supplies from these sandstones, where they are deeply overlaid by later formations, should be prepared to get on with a water more or less contaminated with harder waters from the upper strata.

It is probable that the same conditions as at Grinnell have prevailed more or less in most of the localities where the highest strata belong to any system above the Silurian or at most the Devonian.

The further question might naturally arise as to whether there are in the state so-called "mineral waters." Yes, too many. Of course the term mineral water has no scientific meaning, as gener-

lly used. All natural waters are more or less mineralized and in his sense they are mineral waters. As commonly used, however, he term is applied to such waters as are supposed to have special nedicinal value.

The writer firmly believes that in this sense "mineral waters" ind the traffic in them are to be placed in the same class with patent medicines. He believes that the best waters are those which contain moderately small amounts of the usual mineral constituents, and are as free as possible from bacteria of disease and all forms of contamination. It is very probable that the beneficial effects derived from mineral waters are indirect. In some cases it must be admitted, that undue acidity of the stomach, and of the urine and a low alkalinity of the blood or the secretions may be corrected by alkaline waters. In a very few waters enough lithium has been found to give some medicinal benefit, perhaps, if the patient persistently drank the water to the full extent of his capacity. Of the indirect influences are, the faith element, the freedom from business and other worry and work when visiting mineral springs sanitariums, the early morning walk to the springs and the cleansing of the stomach by generous draughts of water before breakfast.

Recently the Department of Agriculture made analyses of about fifty of the best known commercial mineral waters and published the results in Bulletin 91 of the chemical series. It is interesting to compare some of these analyses with those of Iowa waters. With the exception of a few salt waters and a few highly carbonated waters to which there are no analogues in Iowa as already stated, also two or three waters with high lithium contents, all the other mineral waters can be paralleled in all essential respects over and over again, by Iowa waters. In order to show the compositions of a number of Iowa waters and also to compare them with the commercial mineral waters I have constructed three tabular statements. Table (7) shows light mineral waters in comparison with what may be considered normal waters of similar amounts of mineral constituents, taken from Lake Michigan and the drive wells at Atlantic, Iowa. So far as the mineral matter is concerned there is no evident reason why one should prefer one water rather than the other.

Table (8) shows moderately mineralized commercial waters and their Iowa parallels. It may be observed that the famous Buffalo Lithia water contains .04 part of lithium, which would require one to drink 800 liters to get the medicinal dose. Lithium occurs in some Iowa waters also but so far as known its amount has not

been determined. It may be said that a large proportion of advertised lithia waters do not contain more than a trace of this element, and sometimes none at all.

Table (9) shows heavily mineralized waters, the kind we want to avoid and case out in Iowa well operations. In the best of them one would have to drink 350 liters of water and with it nearly a kilogram of other mineral matter to get a dose of lithium.

While Iowa has few rivers or lakes that are capable of affording good and abundant water supplies, and deep drillings are not markedly successful in a large portion of the state, there is a large compensation in the fact that the state is mostly covered by thick drift which in many localities may supply excellent water and abundant for smaller towns and for farm use. There are great numbers of drift wells from 50 to 300 feet deep. The quality of their water varies widely with locality. Table (10) shows the quality of the waters of a few such shallower wells taken at random. In several sections the wells are flowing.

The subject of the shallower and artesian wells will be discussed in a future communication.

TABLE I.

FROM WAUKON WEST, SECOND TIER OF COUNTIES.

	Stratum.	Depth.	Solids.
Waukon	Jordan (?)	600	282
McGregor	Basal S. S	520	484
Calmar	Jordan	1223	306
Charles City	Basal S. S	1588	282
Mason City	Basal S. S	1277	350
Algona	St. Peter	1050	540
Emmetsburg	St. Croix	965	410
Sanborn	St. Croix	1256	2189
Hull	Algonkian	1256	2364

TABLE II.

FROM DUBUQUE WEST, FOURTH TIER OF COUNTIES.

	Stratum.	Depth.	Solids.
Dubuque	Basal S. S	900-1300	270
Manchester	Basal S. S	1870	494
Waterloo	St. Peter	1170	459
Webster City	Trenton	1250	1023
Manson	Maquoketa (?)	1250	670
Holstein	St. Peter	2004	1491
Sioux City	Algonkian	2011	1986

TABLE III.

From Clinton West, Sixth Tier of Counties.

	Stratum.	Depth.	Solids.
Clinton	B. Sandstone	1065	400
Tipton	B. S	2696	330
Amana	Jordan (?)	1640	1033
Homestead	Basal S. S	2224	1239
Grinnell	New Richmond	2002	870 to 1500
Des Moines	Jordan	3000	2910
Dunlap	St. Peter (?)	1535	1385

TABLE IV.

Lansing to Keokuk, on or Near the Mississippi River.

	Stratum.	Depth.	Solids.
Lansing	Basal S. S	668	451
McGregor	Basal S. S	520	488
Monona	St. Peter	420	421
Manchester	Basal S. S	1870	494
Dubuque	Basal Sand S	900-1300	270
Monticello	Jordan	1198	408
Sabula	St. Croix	973	298
Clinton	Basal S. S	1065	400
Wilton	New Richmond	1360	1146
Davenport	St. P. to B. S	800-2100	1066
Burlington	Pre Cambrian	2430	1082
Ft. Madison	Kinderhook	680	1970
Keokuk	Maquoketa	767	3600

TABLE V.

South from Calmar, Winneshiek County, to Centerville.

	Stratum.	Depth.	Solids.
Calmar	Jordan	1740	306
Oelwein		1000	395
Vinton	N. Richmond	1402	558
Amana	Jordan (?)	1640	1033
Homestead	Basal S. S	2224	1239
Washington		1617	1630
Ottumwa	L. Oneota	2200	1155
Centerville	L. Oneota	2495	1746

TABLE VI.

From Mason City to Des Moines.

	Stratum.	Depth.	Solids.
Mason City	Basal S. S	1277	350
Hampton	Jordan	1708	395
Ackley	Jordan	2032	604
Nevada	Above St. P	980	2280
Des Moines	Jordan	3000	2910

TABLE No. VII.

LAKE MICHIGAN AND ATLANTIC, IOWA, WATERS AND LIGHTLY MINERALIZED COMMERCIAL WATERS.

	SiO_2	SO_4	HCO_3	Cl	Fe	Al	Ca	Mg	Na	K	Li	Solids
Lake Michigan...	5.2	6.8	144	2.2	.....	.2	32	11	3	....	.....	204
Atlantic, Iowa....	22	30	144	10	1.4	2.6	43	13	10	....	.....	276
Otterburn Lithia, Virginia.......	43	2.8	112	4.6	1.5		21	7	8	2	.03	201
Sublett Lithia Danville, Va....	31	6	166	10	1		37	12	15	3		288
Great Bear, Fulton, N. Y......	10	9	118	21	....		31	10	10	2	.....	299
Bear Lithia.......	15	3	115	2	1.4		18	10	5	2	.....	172
Thompson's Bromin, Va........	62	6	81	3	1		7	2	22	3	.....	191

Nitrates and ammonia omitted.

TABLE No. VIII.

MODERATELY MINERALIZED COMMERCIAL WATERS AND IOWA WATERS.

	SiO_2	SO_4	HCO_3	Cl	Fe	Al	Ca	Mg	Na	K	Li	Solids
Buffalo Lithia	35	405	85	11	.....	.5	166	6.4	31	4	.04	744
Rolfe, Iowa	28	145	261	7	2	2	176	9	34	....	....	664
Allouez, Wis.	21	59	360	31	.....	.8	87	43	20	2	....	623
Clinton, Iowa	9	63	306	54	.2	1	60	21	90	4	....	608
Pleasant Valley, Va............	20	1.6	315	3	.....	1.5	53	28	7	2	....	431
Golindo Litha, Staunton, Va...	12	33	333	3	.....	.3	74	29	5	3	.1	492
Decorah, Iowa, Spring........ ...	13	19	333	4	.....	.5	78	27	4	1	....	476
Massenetta, Harrisburg, Pa.	12	3	342	2	.....	.3	63	28	4	3	....	457
Dubuque, Iowa...	8	20	310	8	.....	1.2	58	37	7	3	....	452

TABLE No. IX.

HEAVILY MINERALIZED COMMERCIAL WATERS AND IOWA WATERS.

	SiO_2	SO_3	HCO_3	Cl	Fe	Al	Ca	Mg	Na	K	Li	Solids
Geneva Lithia, N. Y...........	14	1520	245	204	.....	.....	521	116	131	4	.1	2755
Farmington, Iowa	13	1658	250	229	.....	1.6	340	112	442	14	....	3059
Berry Hill, Elkwood, Pa.......	27	1686	151	26	.....	1.5	524	59	164	4	....	2642
Bedford, Pa......	36	1727	192	10	.....	2.1	570	138	13	5	....	2694
Tate Springs, Tenn.	21	1460	260	9	.....	2.9	475	121	25	8	.1	2382
Chelsea, Iowa....	15	1923	240	7	5	2	489	204	38	....	....	2923

TABLE X.

A Few of the Many Good Shallow Wells.

	Depths.	Solids.
Atlantic	60	210
Newton	60	240
Brooklyn	180	509
Bageley	120	379
Boone	50	409
Browns	100	223
Carroll	120	422
Eagle Grove	400	462
Eldora	200	260
Iowa Falls	240	318
Sioux City	50 to 80	405
Perry	115	347

THE DETERMINATION OF SILICA.

BY NICHOLAS KNIGHT.

The method of procedure depends upon the amount in the substance under investigation and also upon the condition of the silica, whether in the form of sand, or as a soluble or an insoluble silicate. The determination is beset with difficulties, but these are by no means insurmountable. It has been the object of much careful study and investigation and very accurate results are attainable even by persons who have not had much experience in quantitative analysis.

There are two classes of minerals and rocks in which the analyst may be called upon to determine the amount of silica: In silicates proper, in which the percentage of silica is relatively large; and in rocks and minerals like limestone, dolomite, phosphorite, and the various ores of iron and manganese, where the silica content may be quite small.

In the important and growing Portland cement industry, there is often a call for the determination of the silica, as well as for complete analyses of the substances that enter into the cement.

THE PREPARATION OF THE SPECIMEN.

It is very desirable that the substance to be analyzed should be in a very finely divided state. It is usually reduced to a coarse powder with an ore crusher, or with a mortar and pestle of iron or steel. It is afterwards finely pulverized with an agate mortar and pestle. The whole must be thoroughly mixed before beginning the analysis to secure perfect homogeneity. The fine material should be sifted through a piece of fine, clean linen cloth, and the coarser particles should not be discarded, but should be rendered as fine as possible and added to the other portion. To keep only that which is more easily powdered, and to throw away the rest would result in not having a fair sample for the analysis.

W. Hempel[1] has studied the abrading effect of pulverizing hard substances with mortars of iron, glass, agate, and hardened steel. He finds that for grinding hard substances like glass, hardened

1: Zeits, Angew, Chemie 1901, page 843.

steel is much superior to agate, and even green bottle glass is abraded less than agate. In finely pulverizing 10 grams of glass, an agate mortar and pestle 416 grams in weight lost 0.052 grams or 5.2 milligrams for each gram of the glass which was powdered. A hardened steel mortar and pestle of the same weight lost only one-tenth of that amount. It might often be desirable to grind one portion with steel apparatus for the silica determination and another portion with agate for the iron and other determinations.

SILICA IN LIMESTONE AND DOLOMITE.

These rocks for the most part are deep sea deposits and the amount of silica they contain is frequently very small. In some of the layers of the Niagara dolomites of Eastern Iowa, there is less than a half per cent of silica. The silica originated in the wearing away of older rock formations, igneous and metamorphic, as well as from non-metamorphic rocks, by the waves of the ancient seas, or it might have come from the marine fauna and flora. If from the older rocks, the silica can exist in a great variety of forms. It can be grains of pure sand, or small quartz crystals, or any of the numerous kinds of silicates. Ordinary acids would have little or no effect in decomposing most of the silicates. If the silica originated from non-metamorphic rocks, it is usually sand or clay, the hydrated aluminum silicate.

For determining the silica in dolomites and limestones, fusion with sodium carbonate in a platinum crucible is recommended by some authorities, contrary to the practice of many chemists. This does not require as much alkali as does the decomposition of a silicate, $\frac{1}{4}$ to $\frac{1}{2}$ a gram of alkali for each gram of substance being sufficient.[1] After the fusion the substance is transferred to a platinum or porcelain evaporating dish by the use of water and hydrochloric acid. It is evaporated to dryness, stirring to a fine powder. Heating above the temperature of the steam bath accomplishes nothing except where much magnesium is present. Then 120° has been found to be the most favorable[2] temperature. Above 120°, the magnesium and silica will recombine, and the silica will again go into solution with hydrochloric acid. The dry and fine powder is moistened with concentrated hydrochloric acid, then with dilute hydrochloric acid and water, and after standing some time, the silica is filtered off. Two or three evaporations and treatment

1. *P. W. Shimer* in Meade the Chemists Pocket Manual, page 162.
2. *J. P. Gilbert* in Tech. Quarterly, Vol. 3, 1890, page 61.

with acids may sometimes be necessary to remove all the silica. The different portions are transferred with the filter ash to a weighed platinum crucible, and heated with a Bunsen burner and finally with a blast lamp for ten minutes, when it is cooled and weighed. The purity of the silica may be tested with a few drops of dilute sulphuric acid and 10 cc. to 15 cc. of dilute hydrofluoric acid, and evaporating to dryness by which the silica is volatilized. Quartz is especially hard to volatilize and several additions of hydrofluoric acid may be necessary.[1]

Instead of the fusion with sodium carbonate, the fine rock powder can be dissolved in a porcelain evaporating dish, covered with a watch glass and evaporated to a fine dry powder by constant stirring with a glass rod flattened on one end. The powder is moistened with concentrated hydrochloric acid, left on the water bath for a few moments and dilute hydrochloric acid and water are added. The insoluble residue is usually silica or clay, and the purity should be tested with sulphuric and hydrofluoric acids. The purity test may also be made by digesting the insoluble residue for one hour in a platinum dish on the water bath with a moderately concentrated solution of sodium carbonate.

By simply dissolving the rock powder in pure dilute hydrochloric acid and filtering off the insoluble residue, without evaporating the substance to dryness, the silica is often very satisfactorily determined as will be shown later. Kortright[2] calls attention to the adhering of silica to the surface of a porcelain dish, when it has been used to evaporate the substance to dryness, causing a rough coating on the glaze. This can not be removed even by a "policeman" but may be recovered by warming the dish on the steam bath with ammonium hydrate. This phenomenon had been noted by Hillebrand[3] and also by Morse.[4] To obviate this difficulty, it is recommended that platinum evaporating dishes be used instead of porcelain. In a large number of silica determinations made with evaporating dishes of porcelain, we have failed to notice the adherence referred to.

SILICA IN A SILICATE.

In the treatment of a silicate six or eight times as much sodium carbonate must be used as of the rock powder taken. All is thor-

1. Hillebrand Bulletin 305 U. S. Geol. Surv., page 174.
2. Chem. News 95.9, Jan. 4, 1907.
3. *Journal Am. Chem. Soc.* 25, 1192.
4. *Exercises in Quant. Analy.*, page 311.

oughly mixed with a platinum spatula. The covered crucible, always of platinum, is heated for twelve to fifteen minutes with a Bunsen flame, and for about the same length of time with a blast lamp until there is no further escape of carbon dioxide, and the substance is in a state of quiet fusion. The flame should be directed obliquely against the sides of the crucible. This is a necessary precaution as it makes possible the oxidation of the substances rather than the reduction. The crucible containing the substance in a state of fusion is seized with the tongs and given a rotary motion to distribute the contents against the walls by which the melted mass is more easily removed. The mass is extracted with hot water, and hydrochloric acid is added, and the substance is evaporated, stirring until a fine, dry powder results. To hasten the removal of the fused mass from the crucible, hydrochloric acid can be added to it directly. If the fused mass is green it denotes the presence of manganese, and hydrochloric acid would liberate chlorine which would attack the crucible. Under such conditions, nitric acid can be used instead of hydrochloric acid.

Many of the authorities suggest equal weights or molecular weights of sodium and potassium carbonates as the flux by which fusion takes place at a much lower temperature. Hillebrand[1] says, "There is no advantage in using the much recommended, because more fusible, double carbonate of sodium and potassium, or the equi-molecular mixture of the normal carbonates or of sodium carbonate and potassium bicarbonate. As Dittrich[2] says potassium salts are more prone to pass into precipitates than sodium salts and it may be that the higher melting point of sodium carbonate is a distinct advantage. Certainly, for effective decomposition of some rock constituents, a far higher temperature than that of the double salt is required."

Substances which contain a considerable quantity of fluorine can not be treated with hydrochloric acid, as silicon tetrafluoride would be volatilized. Substantially the old method of Berzelius is employed. After the fusion with sodium carbonate, the mass is extracted with water, the residue pulverized as finely as possible, filtered, and the greater part of the silica in the filtrate is removed by precipitation with ammonium carbonate. The precipitate is filtered off, ignited and weighed. The silicic acid which remains in the filtrate is precipitated by ammoniacal zinc sulphate. The

1. Bulletin 305, U. S. Geol. Surv., page 72.
2. *Anleitung Zur Gesteinsanalyse* 1905, page 5.

silica is obtained from this precipitate by treating it with hydrochloric acid, and evaporating as usual to a dry powder. The portion of the original fused mass that is insoluble in water may also contain silica, and this must be removed by evaporation with hydrochloric acid. The equations that express the principal reactions involved are the following:

$SiO_2 + Na_2CO_3 = Na_2SiO_3 + CO_2$.

$Na_2SiO_3 + (NH_4)_2CO_3 = H_2SiO_3 + 2NH_3 + Na_2Co_3$.

But as the SiO_2 is not completely precipitated the ammoniacal zinc sulphate is added:

$Na_2SiO_3 + ZnSO_4 = Na_2SO_4 + ZnSiO_3$.

In all these fusions, the difficulty of securing pure sodium carbonate can not escape attention. The purest specimens on the market usually or frequently contain silica, iron and other impurities, often in considerable quantities. To secure a proper degree of accuracy, the commercial article should be dissolved in pure distilled water, filtered, and allowed to crystallize in a platinum or porcelain dish. If the pure sodium carbonate is not obtainable, its use in an analysis should be avoided whenever possible.

SILICA BY THE LEAD OXIDE AND BORIC OXIDE METHOD OF JANNASCH.[1]

This is worthy of consideration, as it renders possible the determination of silica and the alkalies in the same sample. The lead oxide of commerce so frequently contains impurities that the substance can better be prepared for the analysis by the ignition of pure lead carbonate. The carbonate is prepared by adding the equivalent amount of ammonium carbonate to a boiling solution of lead acetate. The precipitated lead carbonate is thoroughly washed and afterwards dried on the water bath.

With a gram of silicate, 10 to 12 grams of lead carbonate are used, after mixing thoroughly with a platinum spatula. The crucible is gently heated at first with a small flame, and finally the heat is increased until fusion is complete. The substance after fusion is treated in the usual way, using nitric acid instead of hydrochloric acid. It is evaporated on the water bath to a fine dry powder, moistened with nitric acid, and once more evaporated to a fine powder. It is finally treated with concentrated nitric acid and water when the silica is filtered off.

Jannasch also maintains that a silicate can be decomposed with pure alkali free boric oxide. The oxide to be previously fused and

1. *Chem. News, Aug. 2, 1895.*

finely pulverized. After dissolving the fused mass, the boric oxide is completely volatilized with methyl chloride. An advantage of this and the lead oxide method is that they do not introduce alkalies into the substance to be analyzed.

FUSION WITH BISMUTH SUBNITRATE.

Hempel and Koch have obtained satisfactory results by fusing with bismuth subnitrate. A half gram of the powdered silicate is fused with ten grams of the subnitrate. On diluting the filtrate from the SiO_2 with water, a greater part of the bismuth is precipitated as oxychloride, and the remainder is afterwards removed with sulphuretted hydrogen. A silicate can also be fused with borax. It must, nevertheless, be said that the different fluxes mentioned, with the exception of the alkaline carbonates, will answer in certain cases, but they are not of universal application.

SOME EXPERIMENTS IN ESTIMATING SILICA.

1. The Niagara dolomites of Eastern Iowa.

The silica was determined by two methods:

(a) A gram of the finely powdered rock was placed in a small beaker, and covered with a watch glass, a small quantity of hydrochloric acid was added, and the carbonates were dissolved by carefully heating to the boiling point. The insoluble portion was filtered off and its weight determined.

(b) A gram of the powder was dissolved in a porcelain evaporating dish, evaporated and stirred to a fine powder, and treated with hydrochloric acid and water in the usual way. The insoluble residue was finally filtered and weighed. The results of the two methods are as follows:

(a)	.78% SiO_2	(b)	.75%
	.76% SiO_2	I	.73%
	.81% SiO_2		.85%
	.87% SiO_2		.87%

The residues were tested with sulphuric and hydrochloric acids and found to be practically pure silica. Most of the layers of this rock in the vicinity of Mount Vernon will leave a residue on treatment with the sulphuric and hydrochloric acids. The insoluble residue from hydrochloric acid in this particular layer must have been grains of fine, pure sand, or pure quartz crystals.

In the various layers of the rock which we have studied, whether *the insoluble residue* is pure silica or not, the treatment described

under (a) is equally satisfactory with that under (b). Treatment (a) requires much less time and labor than (b).

An analysis of this layer of rock resulted as follows:

$CaCO_3$	53.62%
$MgCO_3$	44.96%
SiO_2	0.83%
Al_2O_3	0.25%
Fe_2O_3	0.34%
	100.00%

The rock is essentially a true dolomite.

2. Silica in the Bedford Limestone.

The specimen was obtained from a quarry near Bedford, Indiana. It is a light-colored rock, fine-grained in texture, and it is widely used and favorably regarded as a building material. It is subcarboniferous limestone. The fine powder was treated as described under (a) and (b) in the foregoing. The following results were obtained: (a) 0.54%; (b) 0.55%. The same results could be obtained whether one gram, three grams, or ten grams were used. The residue in the crucible after treatment with sulphuric and hydrofluoric acids was .13%. This was found to be:

Aluminum and Iron Sulphate	0.08 %
Calcium Sulphate	0.058%
	0.138%

To compare these results with those from an alkaline fusion. A gram of the fine powder was thoroughly mixed with seven grams of purified sodium carbonate, and fused in the usual way. The insoluble residue was found to be .53%. On treating this with sulphuric and hydrofluoric acids, the residue in the crucible amounted to 0.16%. Nothing seemed to be gained by this method.

The first filtrates from the silica were frequently evaporated a second time, but no trace of residue was found.

The analysis of the Bedford limestone resulted as follows:

$CaCO_3$	93.55%
$MgCO_3$	5.42%
Fe_2O_3 and Al_2O_3	0.50%
Insoluble residue mainly SiO_2	0.55%
	100.02%

The concordant results obtained by methods (a) and (b) show that the silica is of the insoluble kind.

When the specimen of argillaceous limestone was first sent out for the co-operative analysis, about two and one-half years ago, we experienced no difficulty in obtaining[1] 18% of silica, all that it contains, by a single evaporation. The specimen seems to have undergone a change and in recent months it has been impossible to secure all the silica even by two or three evaporations. We have been obliged to follow the method of Hillebrand[2] and seek for three or four per cent of the silica in the iron and aluminum precipitates. These are fused with acid potassium sulphate, and afterwards digested with sulphuric acid and heated until fumes are given off. When the silica in the specimen amounts to only a few per cent, the portion that persists in solution is necessarily small. It is usually greater when the silica is determined by an alkaline fusion.

THE EFFECT OF DIFFERENT ACIDS AS SOLVENTS.

Dolomite rock, and ores of iron and manganese were treated with different acids as solvents and the resulting insoluble residue was investigated. In some cases the nature of the residue other than the silica was examined. Each specimen studied was finely ground with agate mortar and pestle until the powder did not feel gritty when placed between the teeth, and it was then thoroughly mixed. About one gram of the powder was used in each determination.

SIDERITE.

(a) A gram of the powder was dissolved in pure dilute hydrochloric acid, and the insoluble residue at once filtered off. This was found to be 6.06%. When treated in the platinum crucible with sulphuric and hydrofluoric acids, the loss of weight representing the silica was 1.44%. A blank test was made of the sulphuric and hydrofluoric acids and no residue was left on their evaporation. No residue was obtained by evaporating the filtrate from the insoluble residue.

(b) A portion of the powder evaporated in a porcelain dish on the water bath and stirred to a fine, dry powder gave an insoluble residue of 6.07%. The treatment of this with hydrofluoric and sulphuric acids showed that 1.45% of silica was present. The residue in the crucible which had the appearance of iron was dis-

1. Chem. News 92.61, Aug. 11, 1905.
2. Journ. Am. Chem. Soc., Nov 1903.

solved in concentrated hydrochloric acid and the iron precipitated with ammonia. There was obtained 4.64% of ferric oxide. The comparatively large amount of insoluble residue, practically the same by both tests, was something of a surprise. The amounts of the ferric oxide and silica are not in proportion to form a silicate, or at best only a portion is silicate. The remainder seems to be iron oxide in such a condition as not to be acted upon readily by hydrochloric acid. The next two experiments tend to confirm this view.

(c) Method (a) was repeated except dilute nitric acid (equal parts nitric acid of a specific gravity of 1.42 and water) was substituted for the hydrochloric acid. This leaves a smaller and lighter colored residue than the hydrochloric acid. The insoluble residue was 1.34%, which proved to be 1.30% silica. On evaporating the filtrate to dryness, a second portion of insoluble residue was not obtained.

(d) Method (b) was repeated, using dilute nitric acid. The insoluble residue was 1.30%, the silica 1.28%. No residue appeared on second evaporation.

The experiments were repeated, using dilute sulphuric acid. The results were unsatisfactory, as the residues obtained were abnormally large, confirming the well-known fact that the ores of iron are not easily soluble in sulphuric acid. A complete analysis of the specimen of ore resulted as follows:

FeO	52.59
Fe_2O_3	4.20
MnO	3.30
MgO	2.68
CaO	0.82
SiO_2	1.45
CO_2	35.00
	100.04

2. Another specimen of siderite was examined, and treated by each of the four different methods described in the foregoing. The following figures were obtained:

	a	b	c	d
Residue, per cent	1.33	1.26	0.85	0.94
SiO_2, per cent	0.91	0.86	0.80	0.85

No residue was obtained on evaporating the filtrates in the foregoing experiments.

A third specimen of siderite was available for examination, and it was subjected to the same treatment as before, with the following results:

	a	b	c	d
Insoluble residue, per cent	0.40	0.36	0.40	0.38
SiO_2, per cent	0.36	0.31	0.35	0.32

DOLOMITE.

Specimens from Mount Vernon, Iowa:

		a	b	c	d
1.	Insoluble residue, per cent	0.83	0.89	0.88	0.83
	SiO_2, per cent	0.50	0.64	0.62	0.60
2.	Insoluble residue, per cent	0.54	0.53	0.58	0.56
	SiO_2, per cent	0.41	0.42	0.41	0.41

When the dolomites are treated with nitric acid, it is impossible to stir the substance to a dry powder at the temperature of the water bath, the large amounts of calcium and magnesium nitrates seriously interfering with the drying.

In the following determinations, a second portion of residue was obtained in nearly every case. It was found impossible to dissolve the substances in nitric acid, and aqua regia was substituted. The results from the different methods are not all concordant.

HAEMATITE

	a	b	c Aqua Regia
Residue, per cent	2.26	2.52	3.19
Residue from filtrate, per cent	0.71	0.22	0.00
Silica from first residue, per cent	1.94	2.23	
Silica from second residue, per cent	0.65	0.22	
Total silica obtained, per cent	2.59	2.45	2.90

MAGNETITE

Residue, per cent	5.76	6.47	11.69
Residue from filtrate, per cent	0.96	0.30	0.30
Silica from first residue, per cent	1.44	2.53	3.09
Silica from second residue, per cent	0.96	0.80	0.30
Total silica, per cent	2.40	2.83	3.39

LIMONITE

	a	b
Residue, per cent	2.25	3.68
Residue from filtrate, per cent	1.60	0.12
Silica from first residue, per cent	2.12	3.52
Silica from second residue, per cent	1.40	0.12
Total silica, per cent	3.52	3.64

A SPECIMEN OF COMMERCIAL MANGANESE DIOXIDE

Residue, per cent	12.76	13.95
Residue from filtrate, per cent	1.32	0.12
Silica from first residue, per cent	7.56	7.81
Silica from second residue, per cent	0.42	0.12
Total silica, per cent	7.98	7.93

A SPECIMEN OF PYROLUSITE

	a	b
Residue, per cent	12.79	14.79
Residue from filtrate, per cent	1.60	0.19
Silica from first residue, per cent	7.92	7.92
Silica from second residue, per cent	0.28	0.19
Total silica, per cent	8.20	8.11

In the case of the siderites and dolomites studied, the simpler method gives results fairly concordant with the more complicated method, and the former is therefore to be preferred. A second evaporation and stirring to a dry powder gave no residue and added nothing to the value of the results. Nitric acid as a solvent of the siderites gave smaller residues than hydrochloric acid. With the ores of iron other than siderite that were studied, as well as the specimens of manganese dioxide, the shorter method, simply dissolving in hydrochloric acid, gave generally as satisfactory results as the longer method.

Among the works consulted or referred to in this paper may be mentioned Bulletin 305 of the United States Geological Survey (Hillebrand); The Chemical Analysis of Rocks, Washington; Miller-Kiliani Analytische Chemie; Treadwell-Hall Quantitative Analysis; Talbot's Quantitative Chemical Analysis; Fresenius' Quantitative Analysis; Cairn's Quantitative Analysis; Clowes and Coleman Quantitative Analysis; Crooke's Select Methods; Morse, Exercises *in Quantitative* Analysis.

SOME FEATURES OF THE CHANNEL OF THE MISSISSIPPI RIVER BETWEEN LANSING AND DUBUQUE, AND THEIR PROBABLE HISTORY.

BY SAMUEL CALVIN.

The courses followed by the major streams of the interior of the North American continent during Paleozoic and Mesozoic times, can not now be pointed out with any high degree of certainty. The numerous upwarps and twistings to which the continental ridge was subjected, caused large portions of what is now North America to be at times above the sea, at other times below, and the drainage was shifted from area to area, from one direction to another. During a period as recent as the late Cretaceous the drainage of the middle Northwest flowed westward into a great sea that overlapped the western part of Iowa and extended away to the Sierras of California. There were no Rocky mountains such as we now know, for it was not until the close of the Cretaceous that the ridges of the Rockies, as a whole, rose above the waters; not until this event took place, could there be a Mississippi valley with extensive surfaces sloping from mountain chains on the east and west toward a central axis; not till then could the master stream of the continent enter upon its permanent career.

During practically the whole of the Tertiary period the axial part of the Mississippi valley was low; the Gulf of Mexico extended to the mouth of the Ohio; the great river and its immediate tributaries meandered sluggishly on a base-levelled plain. Toward the close of the Tertiary, however, there occurred a succession of disturbances, not violent, whereby the central part of the valley was elevated to a height of probably 2,000 feet above tide at what is now the northeastern corner of Iowa. All the streams were quickened by the uplift, and corrasion of the channels proceeded with more or less energy until grade was again reached and the drainage courses were adjusted to the new conditions. Corrasion and upward movement were so balanced that, in general, the streams continued to follow their previous winding courses and entrenched their old meanders. This fact is well illustrated by the

sinuous gorge of the Oneota, or Upper Iowa river in the western part of Allamakee county.

The episode of energetic erosion was preglacial. The work accomplished by the great river during its progress and before the episode came to an end is represented by a rock-walled gorge seven, or eight, or nine hundred feet in depth and four to six miles in width. This old preglacial gorge was deeper than the present one, for soundings, as at Clinton and many other points along the river, show that the channel has been filled with sand and clay and other detrital material to a depth of from one, to two hundred feet. This filling is probably the work of glacial time. Before the glacial period, however, the valley had been widened by recession of its walls, the bluffs rose from the level of the water in gentle, rounded slopes, the lateral valleys were also broadened, the topographic features of the region were practically mature.

Some of the changes wrought in the features of the Mississippi river by the earlier ice sheets, especially by the Kansan and the Illinoian, are recorded in the portion of the valley between Clinton and Keokuk; but there are no clear records of any important changes, referable to the earlier glacial stages, in that part of the gorge lying between Lansing and Dubuque. On the other hand, the latest stage of glaciation, the Wisconsin, has left its impress on the valley from Dubuque northward, in a multiplicity of records of unusual interest. The Wisconsin ice invaded the upper part of the drainage basin of the great river. While the glaciers of this stage did not extend as far south by several hundred miles as some of their predecessors, the volume of ice seems to have been very great, so much so that, during the period when the ice was melting, enormous floods of water poured along all the drainage courses which connected in any manner with the ice margin. Some or all of the streams were loaded to the limit of their capacity with sand and gravel. The Chippewa and Wisconsin rivers deserve especial mention on account of the vast quantities of material which they carried and discharged into the central drainage channel. The old gorge of the Mississippi, widened as it was by weathering and recession of the bluffs until it was far beyond the necessities of the preglacial stream, was now overtaxed by the great Wisconsin floods.

In the normal development of every river valley the spurs and headlands between the lateral gulches assume more or less gentle slopes and become rounded and sodded over as the valley reaches *maturity*. The line marking the foot of the bluffs on both sides

of the stream is very sinuous, curving riverward around the salients and forming re-entrant angles landward at the mouth of every tributary valley or ravine. Furthermore, the opposite sides of the valley show little tendency to anything approaching exact parallelism. Between Lansing and Dubuque,—a portion of the river arbitrarily chosen to illustrate certain features equally well developed elsewhere in the upper valley,—the lateral stream courses show all the characteristics of the normal type of topography, mature or approaching maturity. The sides of the valleys are broadly divergent; the salients are normally rounded, with front slopes and side slopes approximately equal; and there is no very strong suggestion of parallelism between the opposite sides. The Turkey river or the Little Maquoketa may be taken as illustrations. While there are some steep cliffs along these streams, they are not continuous, and those occurring on one side usually face lateral valleys or rounded slopes on the other. The main valley, on the other hand, has the salients truncated, the projecting spurs cut away as if sliced off vertically. The ridges between the side valleys end in frowning precipices while the side slopes retain the characteristics of mature topography (Fig. 1). All short curves have been straightened out as if some great gouge had been driven down the channel, reducing it to a uniform width, clipping off the rounded points and making the walls precipitous, so that vertical bluffs in Iowa face parallel vertical bluffs in Wisconsin (See map, Fig. 2). The precipices are not due to recent undercutting caused by the swinging of the current from one side of the channel to the other. Their parallelism and continuity can not be so explained, and then they present precisely the same characteristics whether the river flows directly at their feet or is separated from them by one or two miles of sloughs and islands (Fig. 3). Neither can the precipices be attributed to the kind of rocks in which the river gorge has been cut, for the walls show rocks of many ages and are of many degrees of hardness, varying from hard limestones to very friable sandstones and soft shales. Furthermore, the tributary streams have cut through precisely the same kinds of rocks, and yet their valleys, at least on the Iowa side, show normal characteristics.

By way of explanation of the peculiar features noted in the major stream there may be offered the probability that the gravel-laden Wisconsin floods were the gouge which cut away the bases of the well-rounded projecting spurs and developed the succession of parallel rock cliffs on opposite sides of the river. As shown in figure 1 the side slopes and back slopes of the spurs still retain all

their old characteristics of topographic maturity; the faces looking toward the stream show all the features of extreme topographic youth. Some of the qualities of very young streams are here imposed on a very old valley.

Another notable effect of the loaded Wisconsin floods was the building of gravel terraces wherever slack-water conditions were present along either margin of the swollen river. Any conditions which checked the onward rush of the stream torrent caused the load to be thrown down in quantities so large as to be a constant surprise to the student of river phenomena. And so now gravel terraces are found where the waters evidently whirled and eddied and backed up into the mouths of the tributary valleys. The very conspicuous deposit (Fig. 4), twenty feet or more in thickness, extending up the valley of an insignificant stream in the western edge of Lansing, may be cited as an example. Gravel deposits are also found wherever the pre-Wisconsin valley had widened out so as to leave a low bench or flood plain rising somewhat above the level of the main channel. The Peru Bottoms, above Dubuque, afford a concrete illustration. Sand and gravel, to a depth of fifty or sixty feet or more, are here distributed over hundreds of acres. Similar deposits are repeated all along the stream from the mouth of the Chippewa southward to Dubuque. Gravels are not common below Dubuque, but trains of sand were laid down in large volume, wherever conditions were favorable, to points many miles below Clinton. In the upper end of Dubuque, toward Eagle Point every graded street cuts into an extensive sand terrace.

Still another event chargeable to the loaded Wisconsin floods was the diversion of the Little Maquoketa river from that part of its preglacial channel between Sageville and the lower end of the city of Dubuque. Couler Avenue extends up the old valley to the city limits, and the road which continues thence up to Sageville follows the pre-Wisconsin trench. Here is an old, well-developed, rock-cut river gorge (Fig. 5), more than a hundred feet in depth, now wholly abandoned as a stream course. In the most erratic and unreasonable way, apparently, the Little Maquoketa, near Sageville, turns away from its old bed and flows northward, seemingly in the wrong direction, for about two miles to its present confluence with the Mississippi. The swollen Mississippi of the Wisconsin stage seems to have divided at the upper end of the Peru bottoms, one swift current flowing close to the bluffs west of the bottoms, the other following the regular channel. The west current cut into the old valley of the Little Maquoketa and used that to its junction with the

ı stream. This current scoured out a deep trench close to 's, but, probably when the floods were declining, it deposited ɜ of its load in the preglacial gorge between Sageville and Du-ıe. After the floods subsided the Little Maquoketa met with resistance in flowing backward along the trench cut by the ; current than it would have encountered in recovering and ring out its preglacial channel. The great gravel ridge or ɜau (Fig. 6), fifty feet high, which now separates the reversed ion of the Little Maquoketa valley from the main river, was ɔtless built up in the slacker water between the two currents. a clear presentation of the relations of the reversed stream to bandoned channel, the small map, figure 7, may be consulted.

DESCRIPTIONS OF FIGURES.

gure 1.—Bluffs a short distance below Lansing, Iowa, showing vertical fronting the river, but with side slopes and back slopes old and rounded—nbination of young and mature topography.

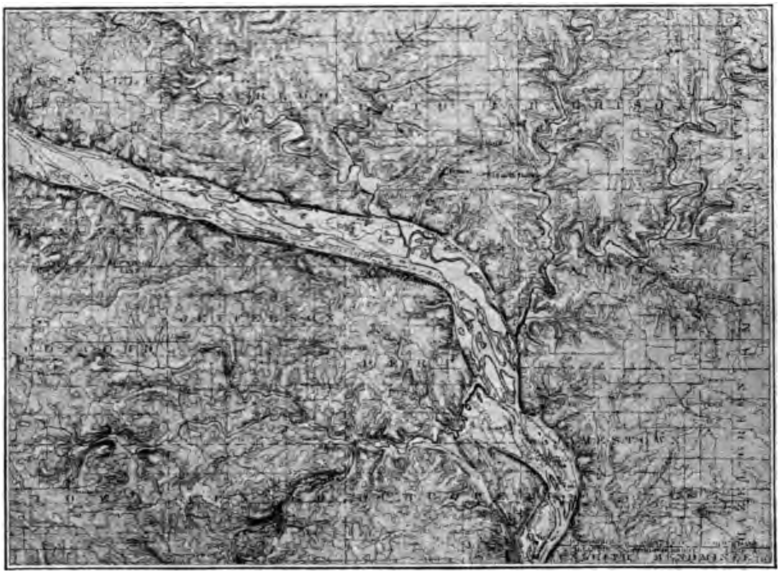


Figure 2.—Map showing the parallel, vertical walls of the Mississippi rive and the normally developed salients and sinuosities of the Turkey river.

Figure 3.—View below McGregor, Iowa, showing sloughs and low islanc occupying the greater part of the flat bottom of the Mississippi gorge, with th *vertical, rocky cliffs* of the Wisconsin side dimly seen in the distance.

Figure 4.—Gravel terrace of Wisconsin age in the ravine west of Lansing, owa, deposited during the high Wisconsin floods.

Figure 5.—The east bluff of the abandoned valley of the Little Maquoketa, etween Sageville and Dubuque. View taken a short distance south of Sage- lle.

Figure 6.—Edge of the high gravel plateau between the reversed portion o the Little Maquoketa valley and the Mississippi river.

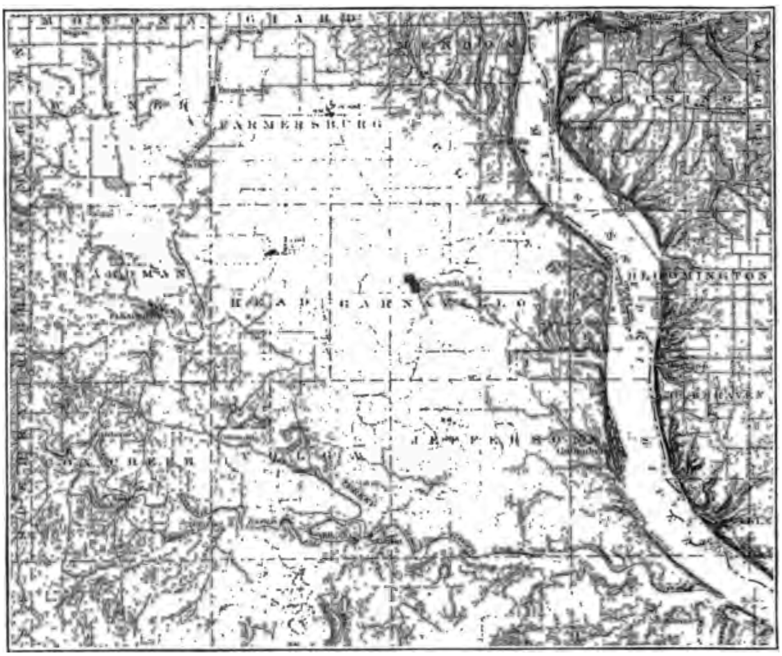


Figure 7.—Map showing the parallelism and vertical walls of the gorge (the Mississippi river, the reversed portion of the Little Maquoketa valley, an the abandoned channel between Sageville and Dubuque.

PHYSIOGRAPHIC SIGNIFICANCE OF THE MESA DE MAYA.

BY CHARLES R. KEYES.

The Mesa de Maya is a small elevated tableland lying on the borders of Colorado and New Mexico, between Trinidad and Raton. It has an elevation of over 9,000 feet above sea-level and about 3,600 feet above the valleys on either side.

This mesa is a part of the Raton range of mountains which trends slightly south of east along the southern boundary of Colorado. It is lava-capped, as are also many other similar flat-topped mountains in the same range. The lava-cap is 500 feet in thickness. On the borders of the mesa is a vertical cliff all around—hence its name, the Spanish meaning "armored mesa."

The Raton range, of which the Mesa de Maya is a part, extends eastward, at right angles, from the Rocky cordillera. The summits of the individual mountains and spurs which go to make up the range are quite even; and many like the Mesa de Maya are covered by remnants of old basalt flows. The general even surface which the range everywhere exhibits, is manifestly merely a fragment of a much more extensive surface that once existed. It is all that remains of an old plain of great extent. This old plain bevels the tilted stratified rocks of its substructure. The old plain is inclined slightly towards the eastward. At the Rocky Mountain front it has an elevation of about 10,000 feet above mean-tide; at the Texas line 130 miles away, it is about 5,000 feet above sea-level. The geological and physiographical relationships are shown in the accompanying diagram:

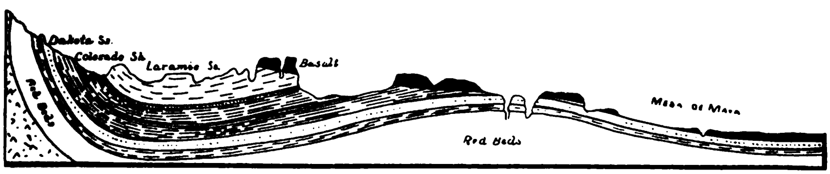


Fig. I.—Substructure of the Mesa de Maya.

The even level, which the top of the Raton range represents, is a physiographic feature that has been given the designation of the Mesa de Maya plain. It is now a mere ragged remnant of a plain

which in Tertiary times was one of vast extent and formed the general upland surface of this part of the North American continent.

The Mesa de Maya plain stands 3,000 feet above another well defined plain which is much better preserved than itself, and at the present time is of much wider extent. This last mentioned plain is called the Ocate plain—from the great Ocate volcano that was built up on this level and over which it poured out its basaltic lavas for hundreds of square miles, thus preserving the plain from the ravages of time.

Ocate mesa or plain lies 500 feet above still another very extensive tableland—the Las Vegas plain, which is now the main upland surface of most of New Mexico, western Texas, Oklahoma and Kansas, and southeastern Colorado. Beneath the level of the last mentioned plain the present waterways have corraded canyons and valleys 2,000 to 3,000 feet still lower. There are besides these principal peneplains many other distinct levels at which general degradation temporarily stopped at one time or another.

Of the old Tertiary peneplanation surface of once so vast extent little now remains outside of the Raton region. When the flatness of a few of these mountain tops disappears and this will be ere long, the last vestiges of this important and interesting plain will be gone. There will be then only a long row of what would be called monadnocks to suggest the existence of a former higher level. The very existence of this plain would then be hypothetical and its height above the Ocate level a matter of conjecture.

The great interest which now attaches to the Mesa de Maya plain is that it is a part of the former great plain still handed down to us on account of the great basalt flows which were poured out over its surface. In place of monadnocks or nothing at all to suggest its former existence as a great peneplain a fragment of that great plain itself remains. Its real significance as an exact measure for late Tertiary can not be overlooked.

In this region of northeastern New Mexico there are, then, four important physiographic levels, 3,000, 500, and 2,000 feet apart. By them it is possible to correlate several important episodes during Tertiary and Quaternary times. The Las Vegas plain probably marks the beginning of Quaternary time in the Rocky Mountain region. With this measure of erosion may be compared the measures of deposition. Above the level of the Mesa de Maya plain there rises, so far as we know, only the central Archaezoic peaks of the southern Rockies.

TERTIARY TERRANES OF NEW MEXICO.

BY CHARLES R. KEYES.

Deposits of Tertiary age are extensively developed in New Mexico. The greatest thicknesses are found in the northwestern and central parts of the state, where their maximum measurements reach no less than 3,000 feet. Many minor areas are also known. These deposits recline usually in marked unconformity upon the beveled edges of the Cretaceous and older strata. They are geologically among the most important deposits of the region.

Tertiary deposits in New Mexico indicate a marked change in the physical conditions of the region as compared with those conditions which prevailed during former geologic periods. In place of open-sea depositions, as was generally the case among all earlier formations, varied conditions existed. In some localities maritime conditions prevailed; in other places another set of conditions occurred, and some of these deposits have been regarded as having originated in large lakes. In still other localities extensive continental deposits were formed and were of fluviatile and eolian origins. The last mentioned class of deposits have a special interest at this time since it is being discovered that many so-called lake beds are not of lacustrine origin but are river formations. The first mentioned classes need no particular description at this time but the conditions under which fluviatile deposits are laid find exceptionally favorable expression. This consideration applies particularly to the Llano Estacado formations and many other deposits having as yet no special geographic designations. This phase of the subject also refers particularly to most of the Quaternary deposits which cover the bolson plains spreading out from the piedmont areas.

The general geologic section of the New Mexican Tertiary deposits may be considered as follows:

Age	Series	Formations	Thickness
Pliocene	Pecosian	Llano Estacado sands	200
Miocene	Arriban	Santa Fe marls	500
		Chaco marls	1,000
	Chaman	Canyon Largo sandstones	700
Eocene	Nacimientan	Torrejon sands	300
		Puerco marls	500

Of the four parts into which the Tertiary time is subdivided the Oligocene has not been as yet recognized by sediments anywhere within the limits of New Mexico. The Eocene, or Early Tertiary, period is represented by at least four important formations and it is quite likely that further differentiation will be found advantageous.

It is proposed to call the basal portion of the Early Tertiary section of New Mexico the Nacimientan series. The term is particularly appropriate as it means, in the Spanish language, birth. The title is taken from the great land grant known as San Joaquin del Nacimiento which lies in Rio Arriba and Bernalillo counties. Nearly the entire section of the New Mexican Eocene deposits occurs within the limits of this grant. The formation also stretches away to the northwestward from the foot of the Nacimiento range of mountains; and the village of Nacimiento is built upon the rocks of this series.

The Nacimientan series has a maximum thickness of not less than 1,000 feet, divisible into at least two well-defined terranes; (1) Puerco marls, about 500 feet in thickness; and (2) the Torrejon sandstones about 200 feet thick. This series is believed to represent a period that is earlier in point of time than any other Eocene deposits. The uppermost member of the Torrejon formation may belong to the earliest or Midwayan stage but it is thought to be somewhat earlier. Its corresponding European stage is the Cernaysian. In a general way the Nacimientan series covers the better known subdivision of the Puerco beds of Cope, but it includes a considerably greater section.

The Chaman series embraces two important formations and some of less vertical extent. It includes the major portion of the New Mexican section generally that has gone under the title of the Wasatch beds.

To the lower part of the series Newberry early* gave the name of Canyon Largo beds. "Long Canyon" drains the interior of the great Eocene plateau of northwestern New Mexico. The canadas of its headwaters reach to the very crest of the high, eastward facing escarpment overlooking the valley of the Rio Gallinas, in Sandoval county. From the top of the facade a vast mesa or inclined plain stretches away a hundred and fifty miles to the northwestward to beyond the Arizona line. This tilted plain is worn out on the beveled edges of Tertiary, Cretaceous, and Triassic strata which have a

* Macomb's Exp. Green River, Geol. Rept., p. 1, 1876.

combined thickness of 10,000 feet. Where the Long arroyo traverses the median sandstone it cuts a deep canyon into this indurated formation giving to the entire waterway its title.

To the lower part of this sandstone terrane Holmes* gave the title of the Pinon Mesa group. The sandstones together with other beds above and below have been also termed Wasatch beds.

Below, the Canyon Largo formation is sharply demarcated. Its massive basal sandstone of bright yellow hue contrasts greatly with the somber colored marls of the Puerco terrane. This basal member of the formation is a conspicuous topographic feature wherever exposed, and rises over the more yielding marls beneath as a pronounced escarpment or perpendicular facade. These characteristics everywhere in the field serve to locate the bottom of the formation.

Above, the Canyon Largo section is not so readily defined as the base. The transition from prevailing sandstones to prevailing marls is not so abrupt as it is from the latter to the marls at the base. The sandstones are prominent beds for a distance of about 700 feet from the bottom of the formation. The vertebrate remains appear to be the most important feature in drawing the exact line of separation between the Canyon Largo and the Chaco terranes. Cope's reference to the shark bed near the top of the formation also seems important in this connection.

The Chaco marls, or uppermost member of the Chaman series, is a formation that is quite distinct from the other parts of the Eocene section, and is easily recognizable in the field. These marls cover the broad Chaco mesa. The southern escarpment of the Chaco mesa is a prominent feature of the landscape of the region and is composed of the sandstones of the Canyon Largo formation.

These marls constitute a part of the section which has been called the upper Wasatch group; and also the Green River shales.

The Chaco marls occupy the central part of the great Eocene plateau of northwestern New Mexico. The geologic structure of the plain being that of a broad, shallow basin the youngest deposits of which are preserved in the middle. All around general planation has removed these beds and older and older and older strata appear as the distance from the center of the basin increases.

The area occupied by the marls of the Chaco formation lies chiefly in northwestern Sandoval county, the southwestern part

*U. S. Geol. Sur. Terr., Ninth Ann. Rept., p. 249, 1877.

of Rio Arriba county, and the extreme eastern part of San Juan county. The present areal extent of the marls is only a small portion of the formation as originally deposited. The existing remnant has been preserved only on account of its position in the bottom of a syncline, the general erosion of the region not yet having reached a level that is beneath the bottom of the terrane in the central part of the trough. No other areas or exact equivalents of the Chaco formation are known elsewhere within the boundaries of New Mexico.

The fact that there are marked unconformable relationships between the beds of the Nacimientan and Chaman series already indicates that a considerable section of Eocene sedimentation is missing in the region. This may mean that all of the Chickasawan stage of the standard American section is represented by an erosion interval and that the beds in question belong to a later stage of the Eocene than has been supposed, corresponding perhaps to the Claibornian stage. Of the European analogues the latest Suessonian or earliest Parisian may be considered the nearest equivalents.

No strata of Oligocene age have been as yet identified within the boundaries of New Mexico. The Eocene and Miocene deposits of the region appear to be separated by an important erosion interval.

The Arriban series of marls is one of great thickness. Its best known member is the Santa Fe marl, although the formation never has been carefully delimited.

The title of Santa Fe marls was first used as a geological term by Hayden* in 1869. He applied the name to certain marls, clays and sands which he found in the Rio Grande valley north and south of the city of Sante Fe. Cope† subsequently studied the vertebrate fossils of these marls and referred the formation to the Loup Fork Tertiary. A few years later Stevenson‡ noted these beds, but, as recently shown by Johnson,§ his name Galesteo group covers the same section as Hayden's title. In a later publication of the geology of the Cerrillos hills, Johnson‖ has extended Hayden's title so as to include also the Quaternary wash-deposits. The upper limit of the Santa Fe marls should probably be regarded as properly located at the base of the vast basaltic flows of the region.

*U. S. Geol. Sur. Terr., Prelim. Field Rept., p. 66, 1869.

†Proc. Acad. Nat. Sci. Phila., Vol. 26, pp. 147-152, 1874.

‡U. S. Geol. Sur., W. 100 Merid., Vol. III, Supp., pp. 159-163, 1881.

§*Sch. Mines Quart.*, Vol. XXIV, p. 316, 1903.

‖*Loc. cit.*

The beds of this formation consist chiefly of sands, marls, and soft marly sandstones. There are some argillaceous layers present, and frequently some coarse materials. For the most part the beds are yellowish or reddish in color. Some of the sand beds are slightly cemented by calcareous material. At the base of the section and resting on the beveled edges of the older strata is frequently a coarse conglomerate bed which is extremely hard and firmly cemented. These "cement beds" may not be confined to the Santa Fe formation alone and probably are not.

The Santa Fe formation has a thickness of over 500 feet. Hayden reports a measurement of 1,500 feet. The base of this terrane is clearly defined. A marked plane of unconformity exists at the bottom of the formation. Wherever this base is observable the beds of this terrane are found to rest on the tilted strata of the older formations.

The upper limit of the Santa Fe formation is not as clearly marked as the bottom. Over a considerable portion of the area which is occupied by the marls the upper layers are mingled with the wash-deposits of nearby mountains. In many cases it may be difficult to distinguish between the Tertiary and Quarternary beds. Inability to separate the formations of the two ages has led Johnson* to extend Hayden's title so as to cover both sections. The facts do not appear to warrant this method of solving a difficult problem. Instead of clearing up the obscure points it causes only more confusion.

A critical examination of the Santa Fe marl sections along the Rio Grande seems very plainly to show that they terminate with the great outpourings of basalt throughout this region. These basaltic flows may then be taken as the upper boundary horizon of the marls. Since that time the Rio Grande has cut its canyon 1,500 to 2,000 feet deep, entirely through the surface eruptive sheets, the marls beneath, into the indurated formations. This has all taken time and is comparable in length to the time consumed in carrying down the thick wash-deposits which now cover the marls and often the lava flows.

The age of the series is no doubt Miocene, corresponding in the main to the Helvetian of Europe.

The Pecosian series appears to be late Pliocene in age corresponding to the Astian of Europe. The principal deposits cover the Llano Estacado of western Texas and eastern New Mexico along the Rio Pecos.

*Sch. Mines Quart., Vol. XXIV, p. 313, 1893.

The title was first applied by Hill* to the Tertiary deposits which veneer the even, seaward sloping plain of western Texas and eastern New Mexico. The thickness of the formation is about 200 feet. All of the beds are to be regarded as of fluviatile origin.

*Bull. Geol. Soc. America, Vol. III, p. 87, 1892.

VOLCANIC PHENOMENA ABOUT CITLALTEPETL AND POPOCATEPTL.

BY CHARLES R. KEYES.

(Abstract.)

Two noble mountains fired the fancies of the native races of Mexico before the Aztecs. Quiescent at present they were within historic time quite active. They are the '"Star Mountain," or Citlaltepetl, and the "Smoking Mountain" or Popocatepetl. Both tower above the great Mexican tableland, itself 7,000 feet above tide-level; the first named on its eastern margin and the last mentioned in the central part overlooking the capital city.

Those scientists who, during the past summer attended the sessions of the Tenth International Geological Congress held in the city of Mexico, and who took part in some of the special excursions, had ample opportunity to inspect these volcanoes in considerable detail.

These mountains are respectively 18,314 feet and 17,876 feet above the sea.

Popocatepetl is the more widely known of the two mountains. At the present time the volcano exhibits little signs of activity. However, a few solfataras exist in the bottom of the chaldron and continue to exhale some aqueous and sulphurous vapors. There is still enough heat to continually melt the snows, in consequence of which the center of the crater contains a diminutive lake. The snow-cap begins at about 14,000 feet.

The lavas appear to be chiefly dark-colored hypersthene andesites with an occasional basaltic flow. The latter are the older. Mineralogically the andesites consist mainly of albite, anorthite, hypersthene and quartz with some orthoclase and diopside. Magnetite illmenite and apatite occur in small amounts as accessories.

The chemical compositions of the andesites, as recently made out by Guild, are as follows:

SiO_2	62.51	58.07
Al_2O_3	16.62	15.83
Fe_2O_3	1.12	2.97
FeO	3.75	3.89
MgO	3.30	5.56
CaO	5.10	6.70
Na_2O	4.28	3.89
K_2O	1.86	1.73
H_2O	.68	.41
TiO_2	1.02	1.27
P_2O_5	.23	.29
Cr_2O_3	.01	.01
MnO	.10	.06
SrO	.03	.04
BaO	.14	.07
Li_2O	Tr.	Tr.
	100.75	100.79

Volcanic phenomena about Citlaltepetl are very extensive and very complex. This volcano is only one of the later manifestations of the general vulcanism of the district. On the slopes and plains below are found many of the very latest and the dying explosive effects. One of the small parasitic ash-cones lies near the city of Julapa.

EXPOSURES OF IOWAN AND KANSAN (?) DRIFT, EAST OF THE USUALLY ACCEPTED WEST BOUNDARY LINE OF THE DRIFTLESS AREA.

BY ELLISON ORR.

McGhee, in the map accompanying his Pleistocene History of Northeastern Iowa, makes the "Upper Till" overlap the "Lower Till." And the eastern boundary line of the "Upper Till" (Iowan), as shown by the same, and consequent western boundary line of the Driftless Area, in the counties of Winneshiek, Allamakee and Clayton, the three northeastern counties of Iowa, begins at the boundary line of Clayton County about six miles south of the mouth of the Turkey River, and runs thence northwesterly at about that distance south of the Turkey, to West Union in Fayette County, and from there runs nearly due north at about an average distance of six miles from the west boundary line of Winneshiek County, to the state line. Leaving all of Clayton but about half of the southwest township, all of Allamakee, and the eastern three-fourths of Winneshiek in the Driftless Area.

On The Preliminary Outline Map of the Drift Sheets of Iowa, 1900, opposite page 372 of Grasses of Iowa, a Supplementary Report of the Iowa Geological Survey, this boundary line is given approximately the same as by McGee. A little more of the southwest part of Clayton,—about equal to four townships,—is represented as being covered by the Iowan, and instead of covering the west one-fourth of Winneshiek County the Iowa Report makes the same formation cover only the southwest corner.

During the past few years the writer's business has made it necessary for him to drive over most of the main roads north of the Turkey river in the three counties named. The country is rolling and in places rough. Owing to the rapid erosion of the hillsides where not grassed over, roadside ditches of great depth are common in the more hilly portions, affording excellent opportunities to study the Pleistocene formations. Our observations show that modified and apparently unmodified deposits and other evidences of drift occur over nearly all of Clayton and Winneshiek counties, and over about one-fourth of Allamakee. The deposits noted were almost without exception originally buried under a heavy mantle of

loess and had it not been for the ditches their presence would not have been suspected.

About the year 1873 the writer's father dug a well near the center of the northeast quarter of section 33, township 96, range 6 west, on the divide between Turkey and Yellow rivers along which ran the Old Military Road from McGregor to Fort Atkinson, and about one mile northeast of Postville. We have a very distinct recollection of the formations encountered but can only give the thickness of each approximately.

After penetrating the usual soil and perhaps 8 feet of loess, yellow boulder clay was struck. The well was dug to a depth of 50 feet when bedded limestone rock was struck. (Bed No. 8, Maquoketa Shales. See page 484, Vol. XV, Iowa Geol. Survey.) The well was a dry one, but was subsequently drilled 15 feet deeper through the limestone into the blue clay (Bed No. 6) where an abundance of water was found.

About half way down, *i. e.*, at 25 feet, a "forest bed" was struck. This bed was several inches in thickness of black earth containing much decayed wood and twigs. One piece about a foot long which had the appearance of a root prong from an old stump was taken out. This was kept as a curiosity for a year or two until it finally fell to pieces.

Below the "forest bed" the clay was blue, and in addition to the granite pebbles and boulders of the yellow clay, there were boulders of quartz and various other kinds of blue, green and red stone, new and strange to the boys who were engaged in the rather hard labor of hauling it out with windlass and chain.

There can be little doubt that the two clay formations struck were the Iowan and Kansan drift with forest bed between. A number of years later a town well was dug at Postville. In digging, the same yellow and blue boulder clay formations with forest bed between were encountered. We can not give even approximately the thickness of the two beds of till, but the forest bed must have been quite thick as a wagon load of black earth and decayed wood was thrown out but no large pieces were found.

In later years hogs rooting at a springy place on the hillside about 80 rods north of the well first mentioned, exposed clay with small boulders.

Eighty rods southeast of the same well, in a slough, the top of a large granite boulder, 2 feet across, is exposed. Three-quarters of a mile southeast in the ditch by the roadside 10 or 12 feet of *yellow boulder clay* is exposed, and at a quarter of a mile further

west on the same road is an exposure of about the same thickness.

Two miles east on the northeast quarter, section 35-96-6, at the head of a small slough, several granite boulders lie at the surface. At one and three-quarters miles north of Postville on the Waukon road, near the top of a hill, a foot or two of yellow till is exposed.

Other unmistakable deposits in Allamakee county have been noted as follows:

At top of hill on road from Postville to Waukon, on the north side of Yellow river, on section line between sections 34 and 35, township 97 north, range 6 west, a heavy deposit of red clay containing a small amount of drift gravel, with greenstone, quartz and granite pebbles quite abundant at the bottom, is exposed.

About 80 rods farther north, on the same road, is a deposit of clay, containing much gravel and pebbles of the usual drift varieties, quartz predominating. Small agates are quite common.

Two miles west of Waukon at the bottom of the ditch on the north side of the road, buried under ten feet of loess, is exposed a few inches of red clay containing drift gravel and pebbles of greenstone and quartz with a few of granite.

On the northwest quarter of section 11-96-6, at a height of about fifty feet above the flood plain of Yellow river and about one-fourth mile from it eight to ten feet of very red clay containing much quartz and greenstone gravel is exposed in a roadside bank.

In Union Prairie township, township 98, range 6 west, Allamakee County, the following exposures may be seen:

On the north side of the road, on the northeast quarter of section 30, a few inches of red clay containing granite and other drift pebbles lies immediately on the top of the Galena limestone. On the south side of the road at the same place is a granite boulder 18 inches in diameter.

By the side of the road, on the southeast quarter of section 13, occasional pebbles of greenstone and granite are found.

Lying just under the roadside fence on the west side of the road where it crosses the southwest quarter of the northwest quarter of section 1, is a granite boulder over two feet in diameter. The road here follows the top of a high and narrow divide between Patterson and Silver creeks.

In Winneshiek County, on the top of the hill just south of Decorah, on the Calmar road, several feet of what is probably Iowan drift, or outwash from it, are exposed. Small granite boulders and pebbles are very abundant in a stiff, sandy, yellow clay.

On the top of the divide between Trout run and the next creek to the north of it emptying into the Oneota river, on section 20, township 98, range 7 west, drift pebbles, gravel and sand are exposed. The overlying loess is very thin at this place.

In Clayton County, the whole of Grand Meadow, that part of Marion north of the Turkey river, and the west part of Monona townships are undoubtedly covered by a drift deposit reaching a maximum thickness of sixty feet. Overlying it everywhere is a deposit of loess averaging from ten to twenty feet in thickness. The underlying rock is Maquoketa.

The exposures are so numerous that in a drive of a few miles on any of the roads traversing that locality a number can be seen.

Notable ones are near center of section 6-95-6, Monona township, on the road from Hardin to Monona; on sections 3, 4 and 5-94-6, Marion township, on the Gunder road; and on southwest of section 3, on Military road, near center of section 8, in the east part of sections 29 and 32, on north and south road, near center of section 11, and near center of section 23, all in Grand Meadow township.

All are the usual exposures at bottom of ditch by roadside.

On the southeast quarter of section 20 of this township, sixty feet of sand and till were penetrated in drilling a well before the underlying Maquoketa was struck.

Near the northeast corner of section 19 in the same township is a deposit of stratified sand, twenty feet of which has been exposed in digging out for building purposes, and on the southwest of section 8 and northwest of section 21 are other "sand banks" from which hundreds of loads have been removed for building.

All exposures in this section are probably Iowan.

On the road from Monona to Elkader, on the section line between sections 11 and 12, Wagner township, and near the center and also the south line of section 24 of the same township, thin exposures of red clay with greenstone and quartz pebbles are seen underlying the thick mantle of loess. On the top of the hill, on the same road, one mile out of Elkader, resting on the Galena-trenton limestone, ten feet of drift of the same character can be seen.

On mile west of Froelich, in section 29, in Girard township, in ditch on north side of road, five feet of clay with characteristic drift pebbles can be seen. Half a mile east, linemen in digging holes for telephone poles, struck sand two feet below the surface into which they penetrated three feet.

One mile east and also one mile west of National a thin stratum of drift underlies the loess.

On the road from Garnavillo to Clayton Center, at one mile west of Garnavillo on southwest of section 7, in the ditch on the south side of the road; about 80 rods farther west on the northeast quarter of section 12, in ditch on north side of road; near center of section 12 in ditches on both sides of road, and near center of section 11 in ditches on both sides of road, under from five to ten feet of loess, are exposed, from a trace to two or three feet of red sandy clay containing an abundance of small pebbles up to a half-inch in diameter, and a good number of larger ones up to occasional small boulders six to eight inches in diameter. About 75 per cent by actual count of those from one to four inches in diameter are greenstone, while of the larger ones, about 10 per cent are granite.

On the road from Elkport to Elkader, about one mile east of Communia, on sections 17 and 18, are thin exposures, and about one-half mile west of this place, about ten feet can be seen on same road.

Two miles from Elkader, where this road descends a steep hill into the valley of a ravine opening into the valley of the Turkey river about half a mile away, fifteen feet of stratified material is exposed.

Three miles west of McGregor on the Monona road, near the top of the John Orr hill, in the ditch on the south side of the road, is an exposure of apparently unmodified drift. July, '06, a section about 20 feet long and 1 foot deep could be seen. While the bottom could not be seen, it probably rests on the Trenton which crops out a short distance down the road towards McGregor. Over it was the blue pipe clay,—about a foot,—and over this the loess. Twenty rods west the road reaches the top of the divide between Sny Magill and Bloody Run, which it follows to Monona. The elevation is probably about 800 feet above the river.

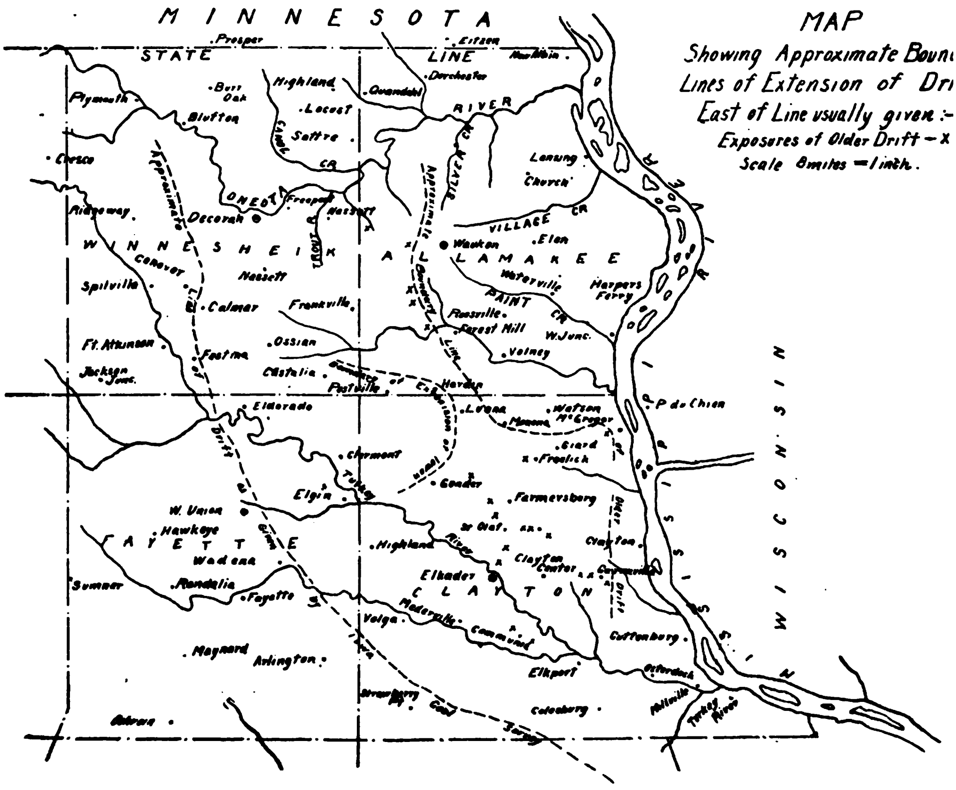
This deposit is composed of small quartz and other pebbles and coarse sand cemented by a red tenacious clay. Pebbles of other material than quartz were often so rotten that they could be crushed in the hand. No granite or syenite was noticed. The largest piece of rock seen was oval, about 6 inches in its longest diameter and four in its shortest, of a tough, well preserved material resembling quartz.

Only the most noticeable exposures noted are given here. Traces of till or modified drift and scattering pebbles and small boulders *are found wherever* the bottom of the loess is exposed, over the *entire area observed.*

The deposits rest on the Galena-trenton and Maquoketa formations which form a peneplain extending from the Niagara escarpment south of the Turkey river, northward to central Allamakee. This peneplain is much cut up by the valleys of the streams tributary to the Turkey and Yellow rivers. No valley trains or other evidences of outwash are found in any of these valleys except that of the Turkey. In fact, drift pebbles or boulders are rare in the gravels of these small streams. All exposures are on the high ground at the general level of the country, and if the deposits occupy the valleys they are nowhere exposed.

Our observations lead us to believe that a lobe of the Iowan ice-sheet extended eastward between the Turkey and Yellow rivers to within a few miles of Monona, and that an older one, Kansan or sub-Aftonian extended eastward to Waukon, McGregor and Garnavillo.

Only a remnant of this till deposited by the older ice-sheet probably now remains on the higher lands, that in the valleys being entirely carried away by erosion.



THE LOESS OF THE MISSOURI RIVER.

BY B. SHIMEK.

No obstacle has presented itself more persistently in the way of those who have attempted to explain the formation of loess deposits by aqueous or glacial agencies, than the presence of the remains of strictly terrestrial mollusks in the deposits.

At first the advocates of the aqueous and glacial theories attempted to brush aside the entire question by mere reference to "land and fresh-water shells" in the loess, or specifically sought support for their contentions in the presence of the few fresh-water forms which occur in the deposit.

But when it was demonstrated beyond question that the vastly preponderating proportion of the shells consists of strictly terrestrial forms, and that the relatively scant fresh-water species are all inhabitants of small ponds or pools, and that no fluviatile species occur, many of the former advocates of the aqueous theory abandoned or modified their earlier views. But there remained those who still sought solace in the presence of the few fresh-water forms, and one positively declared* that "many land forms may exist in an aquatic formation, but the existence of a single aquatic fossil in the loess requires the presence of water."

Another, confessedly unfamiliar with the subject, misinterpreting, and through this lack of familiarity misrepresenting the statements of competent conchologists, has questioned the correctness of the present writer's identification of the terrestrial shells, and suggested that they may be fresh-water forms.†

Still other writers‡ have adopted the comfortable method of simply disregarding the presence of the fossils, or barely mention-

* Annual address of President N. H. Winchell: Bull Geol. Soc. of Am., vol. 14, p. 145, Agr., 1903.

† Miss Luella A. Owen, Am. Geologist, Vol. XXXIII, pp. 223-228, Apr., 1904, and Vol. XXXV, pp. 291-300. The former paper has been noticed by the writer in the Bull. Lab. Nat. History, State University of Iowa, Vol. V, pp. 369-381. In the second paper the statements of Dr. Gill and Mr. Gratacap were not given in their correct relation to the question, as the writer ascertained by direct and indirect correspondence, and Miss Owen's argument, based on a misconception of these statements, is wholly without value.

‡ As, for example, Prof. W. H. Norton in the reports of the Iowa Geol. Survey on the Geology of Linn (Vol. IV), Scott (Vol. IX) and Bremer (Vol. XVI) counties.

ing them but suggesting no explanation or significance of their presence.

But the most remarkable effort of those who, appreciating the need of an explanation of the presence of the terrestrial forms, but still adhering to the aqueous hypothesis, appears in the attempted explanation of the presence of the terrestrial shells in the loess offered by Prof. J. E. Todd, who strives to show that the surface shells were dropped into crevices, or were covered by the creeping of the loess, and were not contemporaneous with it. This explanation was first suggested by Professor Todd in the report of the Missouri Geological Survey.* It was again presented by the same author before this Academy Dec. 29, 1897, in a paper entitled "The Degradation of the Loess," but it was so thoroughly demolished in the subsequent discussion by Professor Calvin and others, that that portion of the paper containing the attempted explanation was withdrawn from publication, and does not appear as a part of that paper printed in the Proceedings of this Academy.† Without submitting further evidence Professor Todd now comes with a repetition of this explanation in a paper read by title at the last meeting of this Academy.‡ In the Missouri report, Professor Todd simply refers to "the fossils which have been introduced extensively in the creeping and cracking of the deposit."

But in the more recent paper, he attempts to present a more complete statement of his view, which however, does not materially differ from the presentation of nine years ago, as the writer recalls it. He bases his view on the following observations and opinions: First, the loess along the Missouri river shows frequent slipping and step-faulting. Second, most of the fossil localities are on hill sides and near streams. Third, the shells were gently entombed by the creeping loess.

It is evident that Professor Todd has limited his observation largely to the immediate vicinity of the Missouri river, otherwise he would scarcely have set forth the first two of these propositions as characterizing all loess. Step-faulting is indeed common along the Missouri, and also the Mississippi, especially on the eastern side. If fossils were limited to the steep slopes which are most subject to this creeping and faulting, there might be some reason in this contention. But unfortunately for Professor Todd's view, innumerable examples of fossiliferous loess occur in localities and

* Vol. X, p. 129, 1896.
† *Vol. V, pp. 46-51, 1898.*
‡ *See Proceedings*, Vol. XIII, pp. 187-194, 1907.

situations in which such faulting is entirely out of the question.* It should be noted that faulting and slipping is not so universal as might appear from his statement. In many localities with gentler slopes and flatter areas where fossiliferous loess occurs, there is no evidence of such slipping and faulting in fresh cuts. In such localities it is only the faces of road and older railway cuts that present this phenomenon, and that on a small scale. Yet in the newest cuts, which present no evidence of slipping, continuous fossiliferous deposits, approximately horizontal or following the rather flat contours, may often be traced for considerable distances.

The writer has observed such continuous deposits in fresh cuts in the Gaulocher brickyard at Iowa City, in the first cut west of Iowa City on the electric line, in the Danner cut near Coralville, and at other points northward on the same line, along the Chicago Great Western railroad just southwest of Carroll, along the Mississippi Central railroad near the foot of Union street in Natchez, Mississippi, and in other street, road and railway cuts, both fresh and old, in various parts of the Mississippi valley.

In all these cases the slopes were so gradual that absolutely no evidence of step-faulting appeared, as evidently none had occurred. Yet the fossils were scattered in practically horizontal continuity, in some cases through several hundred feet of these deposits, and to a depth of from one to more than twenty feet. It is impossible to conceive of a method of cracking and slipping by which it would be possible to introduce these shells after the formation of the deposit, and give to them their present horizontal distribution.

It would be especially interesting to hear Professor Todd's application of his explanation to cases like that at Carroll, where a fossiliferous loess underlies a distinct non-fossiliferous loess, or that at Muscatine where a fossiliferous loess lies under the Illinoian drift. In the first case the first long cut along the Chicago Great Western R. R. southwest of Carroll, Iowa (See Plate I, fig. 1), exposes several feet of Kansan drift over which lies a bed of bluish-gray loess varying from two to four feet in thickness. This loess is very fossiliferous, and the fossils are scattered throughout its length, but above it a layer of distinctly different yellow loess, several feet in thickness, shows no trace of shells. An exposure facing Hershey Ave., near Green street in Muscatine, Iowa, shows about three feet of bluish-gray fossiliferous loess resting upon Kansan drift, and covered by several feet of Illinoian drift. It appears as a light

*Some of these localities were mentioned in the discussion in 1897, and must have escaped *Professor Todd's memory*.

band (a) in Plate I, fig. 2. Another suggestive case is figured in Plate II, fig. 1.

If Professor Todd's explanation of the introduction of the fossil shells is correct how and when did the fossils reach the buried loess in the two preceding, and many similar cases?

Professor Todd's statement that the fossil localities are on hillsides and near streams, needs very material modification. While it is true that fossiliferous loess is most abundant on slopes and near rivers, this fact does not support Professor Todd's contention. The living forms are today most abundant in such localities, as they no doubt were upon the successive surfaces presented during the deposition of the loess. But they are not restricted to such localities. In many cases fossiliferous loess occurs at points remote from larger streams, often on but slightly sloping surfaces, and not infrequently it forms the topmost portions of elevations.

Conspicuous examples of fossiliferous loess exposures at points remote from the larger streams which are bordered by much loess, are the following:

1. The vicinity of Clarkson, Neb., more than sixteen miles north of the Platte river, and with no large stream near.

2. Bruno, Neb., about twelve miles south of the Platte river, and without streams in the immediate vicinity.

3. Lincoln, Neb., nearly thirty miles from the Platte, and with no large stream near.

4. The territory between Carroll and Harlan, Iowa, along the Chicago Great Western R. R. which includes a part of the great divide, is of this kind, the streams for many miles around being small and with narrow valleys.

In all these cases abundant fossiliferous loess is present at high altitudes, and not in close proximity to streams. The loess materials in these cases were probably brought from more remote points,—chiefly from distant larger streams,—but the shells were local.

In addition to these more remote points, there are many other localities irrespective of position with reference to streams, which show abundant fossils in flatter areas which are not subject to extensive faulting. A few are here cited:

1. The loess-covered territory south of Larchwood, Iowa, which is rather sparingly fossiliferous on the broader uplands.

2. The first cut northeast of Carroll, Iowa, on the Chicago Great Western railroad. This cuts through a low ridge, and exposes the following section, beginning below: Kansan drift, *gumbo, a very fossil*iferous post-Kansan loess, a yellow post-Iowan

loess, Wisconsin drift, and in places a thin veneer of a soil, resembling and corresponding to loess.

3. The low cuts along the M. P. railroad about two miles west of Nebraska City, Neb., in an undulating plain. The lower, post-Kansan bluish-gray loess contains an abundance of fossils.

4. Several exposures on the plateau on which Natchez, Miss., stands show numerous fossils.

5. The undulating loess-covered area surrounding Cannonsburg, Miss., is quite fossiliferous, as shown in railway cuts.

6. Several exposures in and near Iowa City, notably the first C., R. I. & P. R. R. cut west; the exposures near the cemeteries; and numerous exposures along the roads leading west and southwest.

7. Here may also be noted the Chicago, Rock Island & Pacific railroad cut in the uplands just west of Davenport. This was reported upon by Professor Pratt* in 1869. He described the loess as under a "gently sloping prairie," and speaks of the "horizontal position of the strata,"—characters which are still evident. The loess here contained shells "extremely fragile, but unbroken."

These localities and many others like them, offer a sufficient response to Professor Todd's statement that "until we have evidence from the central masses of loess, *i. e.*, deep below a flat surface, where fissuring or wash could not be postulated, there will be reasonable doubt." Fissuring and wash sufficient to produce the deep vertical and broad horizontal distribution of the fossils in many of these exposures certainly cannot be assumed even by the wildest flight of imagination.

Moreover there are very many localities, both along the Missouri and elsewhere, in which fossiliferous loess occupies the tops of ridges, as well as lower slopes, and the shells often appear at the very surface of the topmost portions of the elevations. The following are conspicuous examples:

1. The top of the hill on which the reservoir is located at Arion, Iowa. The hill rises 150 feet above the valley. There is no large stream near. (Plate II, fig. 2.)

2. The top of the hill just south of Carroll, Iowa, along the wagon road leading south. The fossils here are almost at the surface.

3. The top of the ridge in Hamburg, Iowa.

*Proc. Davenport Acad. Sci., Vol. 1, pp. 96-97. Read in 1869, published in 1876.

4. The very summit of King Hill, and other elevations in St. Joseph, Mo. The fossils are here very abundant at the extreme summit, which is about 250 feet above the valley.

5. The cut near the New Orleans & Northwestern railroad depot in Natchez, Miss.*

6. A cut near the corner of Walnut and South streets, and several other cuts, especially northward, in Vicksburg, Miss.

In all these cases the fossiliferous loess extends over the topmost portions of the hills where faulting and fissuring are least noticeable, and where the horizontal distribution of the fossils is so uniform that the introduction of the shells through fissures is inconceivable.

That the fossils of the loess should have found their way into the deposit in the manner suggested by Professor Todd is so contrary to all the facts which may be observed even without getting out of sight of the Missouri river, that in presenting this view he has shown an utter lack of that "scientific caution" which he himself gratuitously suggests to the writer.

The following considerations are especially worthy of notice in this connection:

1. If the fossil shells had been carried downward from the surface as Professor Todd suggests, there should be a preponderance of these shells in the upper part of the deposit. As a matter of fact they are frequently abundant at considerable depths and lacking nearer the surface.

2. The shells should in that case frequently, if not usually, appear in vertical or oblique lines marking the old fissures. In truth, the shells are usually in continuous bands, either horizontal or following vertical contours.

3. The shells should be absent from the topmost portions of higher elevations and from horizontal or gently sloping loess deposits. In reality they are frequently abundant in both, as already stated.

4. If the shells had simply fallen or crept into fissures we should, at least occasionally, find comparatively fresh shells at some distance below the surface. In an experience covering more than twenty-five years, during which the writer has examined fossiliferous loess in innumerable sections from Wisconsin to Louisiana, and from Indiana to Nebraska, he has not seen a single specimen of this kind below a depth of a few inches, nor has he learned of such a case.

*See *Am. Geol.*, Vol. XXX, Pl. XII.

5. Where a distinct creeping of the loess has taken place "on steep slopes, when the lower portion has been rendered plastic by moisture," the fossils in the deposit are as a rule, so badly crushed that it is impossible to secure perfect specimens even where fossils are abundant. The writer has observed shells thus crushed by evident creeping and slipping, at Natchez and Vicksburg, Miss.; Helena, Ark.; St. Joseph, Mo.; Council Bluffs and Missouri Valley, Iowa; Omaha, Neb., and other points. This creeping or faulting takes place chiefly, if not wholly, while the loess is moist, and when it is in that condition its fossils are as a rule soft and very frail, and hence easily crushed by the slightest movement of the bank.

The perfection of the most delicate fossils in the great majority of fossiliferous exposures is sufficient proof that such movements have not been general.

So far as concerns Professor Todd's references to the occurrence of fossil localities on hillsides and near streams; to the presence of non-fossiliferous exposures "in apparently equally favorable locations," and of their occurrence at points remote from streams, they are wholly irrelevant.

The variations in distribution have been discussed by the writer,* who has repeatedly pointed out the striking similarity in the distribution of modern and fossil forms in various localities. Students interested in these problems, who will go to the field and carefully compare the distribution of both living and fossil forms, will be convinced of this similarity, and will appreciate the fact that it is evidently caused by like conditions,—conditions such as now prevail over the same area.

The inequality of distribution of the fossils which has so attracted Professor Todd's attention, is exactly duplicated by the modern forms. A grove, remote from a stream or adjoining it, may have many living mollusks, while another, in either situation and seemingly similarly placed, may have none. Prairie areas, wholly without woody plants, will have few or no living mollusks, and as the greater part of the territory remote from streams throughout the Mississippi valley is prairie, its molluscan fauna is limited and local.

Similar conditions in all probability prevailed during the formation of the several loesses (one following each glacial drift), and

*See especially Proc. Ia. Acad. Sci., Vol. VI, pp. 98-111, 1899, or Journal of Geol., Vol. VII, pp. 122-136, 1899.

as the shells were gradually buried, the fossils retained the same peculiarities of distribution. In localities where more than one loess occurs, changes in local conditions frequently produced one loess with fossils, and another without.

Creeping and slipping evidently do not materially influence the peculiarities of distribution of the fossils, for these are related to, and consistent with those of the living fauna.

Equally unfortunate is Professor Todd's attempt to explain the absence of the fresh-water mollusks from the loess by reference to the possible coldness of the water, and to its muddiness.

Modern fresh-water shells are exceedingly abundant in some localities in the far north; on the other hand they are almost completely absent from the loess of the far south, where it is certain that at no time in the later history of the continent, cold could have caused this absence, and where the remains of land shells are in large part those of species which are almost sub-tropical. Throughout the Mississippi valley modern fresh-water shells are abundant, and they were probably equally abundant during the time of the deposition of loess, for the much more abundant terrestrial shells point to conditions similar to those of the present. The fresh-water shells were not buried in the loess simply because it was not deposited in water, in which they lived.

The muddiness of the streams equally fails to account for the absence of fresh-water mollusks. Even continually muddy water is not necessarily fatal to mollusks. For example in the brick-red Washita river of Oklahoma, with its perpetual burden of silt which exceeds in amount for every cubic unit even that of the Missouri, fresh-water mollusks are locally common.

The absence of mollusks from a large part of the Missouri river is due probably in very large part to the constant rapid shifting of the bottom of that stream. But even granting that mud destroys molluscan life, the absence of fresh-water mollusks from the Missouri river loess is not explained on this ground. This loess extends along many of the tributaries of the Missouri, and these tributaries are not perpetually muddy, and nothing indicates that they ever were muddy throughout the year, like the Missouri. These tributaries now contain an abundant fresh-water molluscan fauna, and they have no doubt sustained it during all the time which has been favorable to the terrestrial mollusks which have inhabited the region from the time of the beginning of the loess deposition. Yet no fluviatile fossils have been found in the loess bordering them.

Certain other points in Professor Todd's paper are worthy of attention. His closing statement concerning the relative abundance of loess on the east and west sides of the Missouri river is astonishing in view of his experience along that stream. Surely anyone who has taken the trouble to compare the deposits of loess on the opposite sides of the river at St. Joseph, Mo., and Wathena, Kan.; at Forest City, Mo., and Rulo, Neb.; at Pacific City, Iowa, and Plattsmouth, Neb.; at Council Bluffs, Iowa, and Omaha, Neb. (where the difference seems to be least of all, but is nevertheless striking); at Missouri Valley, Iowa, and Blair, Neb., and at Sioux City, Iowa, and opposite Nebraska points, will scarcely speak of a merely "slight excess" on the eastern side, when in fact the loess on the east side is almost uniformly very much thicker, as it is along the eastern side of the Mississippi river. So far as the writer's observations show, the thickness of the loess on the east side of the Missouri river averages fully twice that on the west side, though it must be borne in mind that it is extremely difficult to give exact ratios as the loess is very variable in thickness on both sides of the river. But that the average thickness of the loess is greater on the eastern sides of the Mississippi and Missouri rivers is undoubtedly true. This, together with the evident close relationship between the distribution of both the loess and its fossils, to the modern distribution of plants which is determined largely by the same forces, and the fact that enormous amounts of dust are now gathered from the bars of such streams as the Missouri, all furnish strong proof that the greater part of the materials of the loess were gathered in the form of dust from river bars. They are not consistent with the suggestion that the materials originated on the dry western plains, and moreover it should be borne in mind that by far the greater part of the loess in the Mississippi drainage occurs along streams which drain drift-covered areas, and that in composition the loess is practically identical with the fine materials of the drift.*

The advocates of the aeolian hypothesis therefore decline to follow Professor Todd's suggestion to search on the dry western plains for the source of the loess materials.

Professor Todd's argument based on the formation of river terraces would have greater weight if the loess was restricted to the terraces along the Missouri and other streams. But fossiliferous

*Compare analyses of glacial clays, p. 250, and loess, p. 282, in the 6th An. Rep. U. S. Geol. Sur., 1885, Chamberlin and Salisbury.

loess is found in such abundance, even in the territory contiguous to the Missouri River, at points remote from the river, occupying, for example, the great divide in Carroll County, Iowa, and a large part of the territory between the Platte and Elkhorn rivers in Nebraska, in many of these cases at the highest points in the territory, and the formation of these deposits in water would call for the flooding of enormous areas. No evidence of such flooding has yet been presented, though the presence of the loess has sometimes been accepted as such evidence. Moreover the presence of the great bodies of water postulated by this view would make impossible such accumulation of land-shells in their silt deposits as we find in the loess.

Perhaps no argument has been more tenaciously adhered to by recent advocates of the glacio-fluviatile hypothesis than that based on the blending or intermingling of drift and loess, which has been urged as proof of the continuity or identity of the glacial and loess periods. Professor Todd offers nothing new on this phase of the question, though he derives much satisfaction from the assumption that it is true. In support of his view he cites Winchell for Minnesota, McGee for northeastern Iowa and Udden for southwestern Iowa. Winchell's references are usually so general that the writer confesses that he has not always been able to follow them in the field. He has, however, examined numerous loess and drift sections in southern Minnesota, and has uniformly found them like those of northern Iowa, without unique features. He is, also, familiar with the territory covered by McGee and Udden and has examined most of the section which they mention, and many others like them.

Two types of this intergradation may be observed in Iowa and adjacent territory. The one is that between the fine sands and the overlying loess which may frequently be observed along the border of the Iowan drift in Iowa, as north of North Liberty; on the east side of the Missouri river, as at St. Jospeh, Mo.; on the east side of the Mississippi river, as at Gladstone, Ill. (see Plate III, fig. 1); and in the vicinity of West Point, Neb. In all these cases the areas in which such intergradation occurs show evidences of having been sand dune areas, or they are directly connected with existing sand dune areas. The intergradation is such as would be produced by the gradual fixing of the dunes by vegetation, and the subsequent deposition of fine materials by wind in the anchorage thus provided. Illustrations of such transformations may be observed on a small scale in modern sand dune areas, as west of

California Junction, Iowa. These areas, therefore, give strong support to the aeolian hypothesis.*

The other type occurs between the Kansan drift and loess, and may be found at various points in Iowa, Nebraska and Missouri. In the Kansan territory the drift is very generally covered with a more or less variable layer, seldom exceeding one or two feet in thickness. It is usually dark (generally blue or reddish-brown), very compact and almost impervious, with pebbles and coarse grains of sand in the lower portions, but the upper parts usually fine, and often grading into loess, the change being usually completed within a few inches. It is the deposit which McGee included as the lowest member of the loess series, and which Udden designates as gumbo.

It is also the same as the lowest of the three "loesses" reported by Wilcox at Red Oak, Iowa, to which Todd refers. Professor Todd states (p. 191 l. c.) that "Udden admits that 'red clay or gumbo' may be a loess," but a reading of the references which he cites shows that Professor Udden simply suggested the possibility that gumbo may be in part old loess which has been modified by subsequent conditions, and that he does not consider it typical loess.

An examination of a large number of sections of this kind has convinced the writer that the gumbo is not genetically the same as loess. The material is harder, more compact, being evidently chiefly a glacial "joint clay," and almost invariably contains pebbles, usually more or less scattered, or coarse grains of sand, at least in its lower parts. So far as the writer's observations show it is wholly devoid of fossils, and none have been reported from it. It often grades downward into true drift, and not infrequently upward into true loess. This latter transition usually occurs within a very short vertical distance, rarely more than from one to six inches. Occasionally the line between the gumbo and the loess is sharp but a slight intergradation is more common.

In its texture and presence of occasional pebbles the transition part of gumbo often resembles somewhat the deposits which the writer has observed in somewhat swampy places on the Wisconsin drift area in northern Iowa, and probably represents an old post-Kansan soil, the first to be formed after the withdrawal of the ice-sheet, probably chiefly by water action. A similar slightly pebbly

*This question will be discussed more fully by the writer in a paper on the "Loess of the Paha and River-ridges."

or sandy heavy soil is now found on the poorly drained Kansan surfaces in Dubuque and Bremer counties, and elsewhere.

If swampy areas, such as are still common within the Wisconsin drift area in Iowa were gradually drained by erosion, a vegetation would soon gain a foothold on the exposed parts. This would at first be scattered, and would retain but little fine material. Every subsequent temporary flooding of the territory during wet seasons would result in the covering of the plants and the mingling of some of the coarser materials with the fine soil accumulated by them. As the drainage became more perfect the flooding would be less frequent, and less coarse material would be shifted, until finally the permanently exposed surface would be densely covered with vegetation and would accumulate a uniformly fine soil, and ultimately a loess.

In such cases the line of demarkation between the drift, sand or muck, and the overlying soil would not be sharp, as may frequently be observed on old sandbars along our streams. The fact that gumbo thus frequently grades up into loess is therefore far from proof that the two deposits are genetically the same, but suggests only a gradual change in conditions during the transition period. The manner in which vegetation starts on a bare loess surface is shown in Plate III, fig. 2, and is of interest here.

The presence of the several contiguous deposits leads Professor Todd to ask: "But how by the aeolian hypothesis can be explained the occurrence of different strata of considerable thickness, clearly delimited and in close contact?" Eliminating the gumbo, with which, as noted, the aeolian hypothesis has little or nothing to do, the question may be readily answered with reference to contiguous loesses. Investigation has shown that the contiguous loesses lie wholly (as far as observed) outside of the several drift borders, or at least near them. The advance of the several ice-sheets was accompanied by a glacial climate the influence of which must have been felt far beyond the border in a territory in which large quantities of ice and snow remained during the greater part of each year. In such territory there would be no evidence of glacial drift, but as all vegetation must have been destroyed on the old surface, and as new materials were brought down by the later ice-sheet which could be re-worked into a newer loess, a decided difference between the newer and older loess would be expected, and the line of demarkation between them might well be sharp, though not necessarily so, especially at points more remote from the ice-border. When the Illinoian *ice-sheet entered* Iowa there was evidently loess on much of the

Kansan. That portion within the Illinoian lobe was removed by the ice, but outside of the lobe only such effect as has been noted would have been produced. In Scott county, Iowa, north of Davenport, several exposures show two loesses, the interval between which evidently marks the time of the presence of the Illinoian lobe near by. Similarly two loesses occur just outside the Iowan lobe at Decorah, near Iowa City and at Carroll, Iowa, the interval between which marks the presence of the Iowan ice. That this view is correct is further attested by the presence of a drift (the Iowan) in the interval, as in the northern part of Johnson county, or by a drift (the Wisconsin) capping the loess as at Des Moines and Carroll.

Thus the presence of several loesses does not weaken the aeolian hypothesis. On the contrary it strengthens it, for each ice-sheet produced new conditions and brought new materials, which during the inter-glacial periods were built up into loess under conditions which produced an abundance of plants and land-snails, a fact which precludes the presence of floods.

Professor Todd again refers to the "interloessial till" found by Dr. Bain and himself at Sioux City. It is worthy of note that the numerous observers who have studied the loess along the Missouri and elsewhere have failed to discover any other "interloessial till." If the conditions assumed by the advocates of the fluviatile hypothesis once existed, such examples should be frequent. It may further be said that the particular exposure in question has not been so carefully studied that its character could be considered as absolutely established for broad conclusions.* It is also a fact that on both sides of the Missouri river the drift frequently rises to form huge cores of the loess-covered ridges, and that it rises much above some of the loess exposures which appear on the slopes, thus making it locally possible to have drift carried over loess during heavy rains.

So long as all this is true, and until Professor Todd brings to light other and later evidences than he has thus far produced, the writer's objection (which he designates as "strictures") to general conclusions which are based upon such insufficient evidence, must stand.

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*In the interval between the presentation and the printing of this paper the writer made a careful examination of numerous sections near Sioux City, among them the sections showing the "interloessial till," and found that the member below this till is not loess, but a heavy joint clay which is evidently glacial and pre-loessial. This removes one of Professor Todd's strongest props, and explains what heretofore has been a puzzle to students of the loess. A more complete account of this and related deposits is in preparation.

In connection with his discussion of the above-noted deposits, Professor Todd calls upon the advocates of the aeolian hypothesis to show cause for claiming that most of the Missouri River loess is of aerial deposition when so many similar deposits are unquestionably of aqueous origin." Before entering upon this task the writer calls upon him to designate exactly where these "similar deposits" are located,—not by reference to books and papers, but to exact localities where they may be studied in the field. The cases which he has thus far cited certainly do not give grounds for his challenge.

In closing, the writer desires to call attention to one more statement made by Professor Todd which is misleading. He states that the writer "postulates timber-clad hills for the habitat of his land shells." In various papers on the subject the writer has referred to the fact that land-snails are most abundant in timber covered areas, but they are not absolutely restricted to them. Other vegetation may furnish food and shelter for some of the species. Nevertheless, if we are to judge of the past from the present the great majority of the fossils once lived upon areas covered with trees or shrubs.

But in that case, he asks, "how can the absence of large root marks be accounted for?" During the spring the writer made an investigation of the loess ridge in which certain human remains were found near Florence, Neb. In the course of this work he had occasion to re-excavate and slightly extend the excavation made by Professor Barbour and Mr. Gilder. The section showed cavities near the surface, left by several large roots, and in the cavities there remained only slight traces of vegetable matter in the form of a brown residue of the consistency of fine sawdust. The walls of the cavity were in many places without discoloration by organic matter, and in wet seasons such cavities would be easily filled by loess without leaving any trace of the root. The same thing takes place with smaller roots in many loess exposures. This decay and disappearance of roots is taking place now, and has undoubtedly continued through long periods of time in which the loess accumulated.

But if Professor Todd finds difficulty in explaining what becomes of the roots in a gradually increasing loess deposit, will he kindly explain what has become of the roots of the countless generations of plants which have undoubtedly developed upon the loess deposits which he assumes to be practically without increment? The upper portions of the loess subsoils ought in that case to be

crowded with such evidences of the old roots as he calls for, yet an examination of the sections shows nothing of the kind.

EXPLANATION OF PLATE I.

Figure 1.—Two loesses over Kansan drift, in the first cut on the Chicago Great Western railroad southwest of Carroll, Iowa. The lower loess is fossiliferous. (From Plate XI, Bull. Lab. Nat. Hist., State Univ. of Iowa, Vol. V.)

EXPLANATION OF PLATE I.

Figure 2.—Bluish fossiliferous loess (a) between the Kansan and drifts. Opposite Hershey avenue, beyond Green street, Muscatine, Io

EXPLANATION OF PLATE II.

Figure 1.—A bank in cut on interurban railway just south of station at Coufals. The lowest stratum is a fossiliferous post-Kansan loess; above it, marked by the four markers, is Iowan sand, which blends with drift to the left; the uppermost stratum is a yellow post-Iowan loess. Neither of the two upper strata contain fossils. (From Plate XII, Bull. Lab. Nat. Hist., State Univ. of Iowa, Vol. V.)

EXPLANATION OF PLATE II.

Figure 2.—Hill at Arion, Iowa, rising 150 feet above the valley, and cappe with loess which is most fossiliferous at the very summit.

EXPLANATION OF PLATE III.

Figure 1.—Loess overlying an old sand dune at Gladstone, Ill. The sand is stratified and grades upward into loess. The latter is marked by the holes made by sand-martins.

EXPLANATION OF PLATE III.

Figure 2.—A nearly vertical bank of loess in Fairmount park, Counci Bluffs, Ia. Grasses and other plants have already gained a slight foothold but they appear only in scattered tufts.

RECENT ALLUVIAL CHANGES IN SOUTHWESTERN IOWA.

BY J. E. TODD.

The region specially discussed in this paper is about five square miles in the northwest corner of Fremont county, Iowa, which is the southwest county of that State. It lies mostly on the bottom lands of the Missouri River. It is bounded on the east by a tableland rising abruptly in steep bluffs cut by deep ravines. These bluffs rise 250 to 300 feet above the plain and are composed mainly of yellowish loam, typical loess. This yields easily to erosion especially when water soaked. At such times, its cementing lime, which when dry holds it firm like a soft rock is dissolved and the mass washes or creeps like wet sand.

The map (Fig. 1) shows the main localities and features. Wabonsie Creek is ordinarily a stream 6-8 feet wide, where it comes from the hills. It has a basin about 27 square miles in extent above that point. Near its egress, around which cluster most of the facts we record, are two lakes, the North or Buckingham Lake and the South or Wabonsie Lake. These were doubtless once portions of the bed of the Missouri River, possibly about the same time, but more likely the south lake is the older, the north corresponding in time to an old channel northwest of the south lake. The turning of the river to its east bluffs at that time may be referred to the influence of Calument Point which stands out conspicuously from the Nebraska side.

It will be found advantageous to narrate the facts recorded, in the order of discovery, rather than in chronological order of their occurrence.

The writer's earliest personal acquaintance with the region was in the early sixties, when he fished in the south lake from the foot of the bluffs near the south line of section 11. At that time no road was possible along next the bluffs southward. Wabonsie Creek followed the bluffs closely in that direction, but old residents claim that it did not enter the lake but turned west to a channel northwest of it.

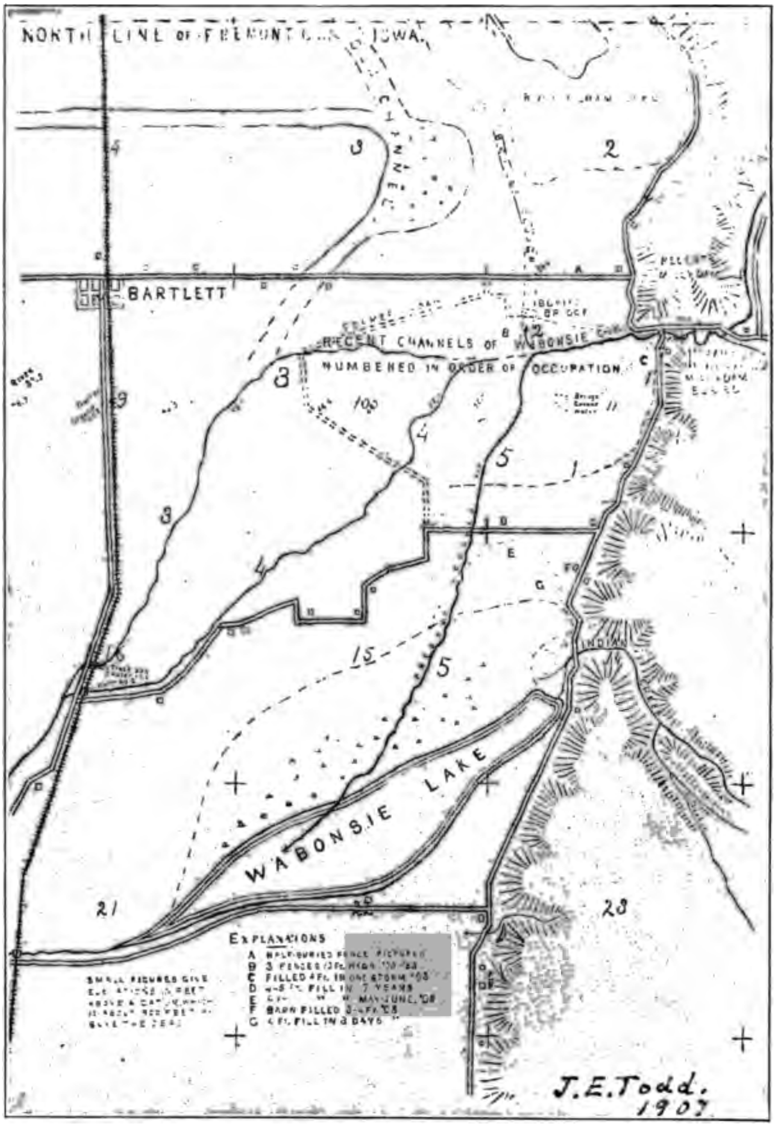


Fig. 1.—Map of part of T. 70 N., R. 43 W., Fremont county, Iowa, illustrating recent changes of Wabansie creek.

On the writer's return to the region in '71, the stream still ran south, but had so built up its bed that it was very sluggish and in time of flood overflowed westward from its egress from the hills. William Holloway who owned the land there repeatedly built low dykes to stop it.

Burson's Mill. Meanwhile, in '72-'73, Joseph Burson, who has furnished the writer with several facts of his own observation, put in a grist mill several rods up the creek, damming the stream still higher up where the valley was narrowed. He had a fall of 9 feet at ordinary stages.

In 1875 the stream so succeeded in cutting out its channel at Holloway's that it kept it permanently and abandoned its southerly course below that point. It then ran nearly straight west to a channel which it followed northward to the north lake. The descent westward was so steep, nearly 30 feet in the first mile, that erosion was rapid and quickly cut down and backward with a receding rapid. When this rapid reached the mill there was a fall there of 20 feet, and the foundations of the mill were endangered.

Emmet's Mill. In cutting back the stream revealed the posts and mill-stones of an old grist mill which aroused much wonder. No one at first seemed to know anything about it. Old residents could tell nothing. Its primitive character was evident. The mill-stones were made of limestone like that in quarries not far away. An old hollow sycamore served as a fore-bay, apparently to an undershot wheel. The old surface at the old mill was buried about 12 feet. The old dam for the mill was also revealed and the old surface in the old mill-pond, where were found stumps cut with an ax, buried 12 to 14 feet.

Conjecture and speculation were rife, and inquiries started which have continued till recently and have brought out the following facts.

When the Mormons were driven out of Nauvoo, Ill., in 1846, many settled in western Iowa, Kanesville (Council Bluffs) being their rendezvous. Most went on to Salt Lake in 1848 but many remained in Iowa.

A man by the name of Emmet put up the mill in 1847 or 8. William Leeka, coming in 1848 engaged the mill-site for a mill which he brought with him but Emmet backed out. Leeka consequently located at the point on Plum Creek afterwards well known as Leeka's Mill, and with better machinery got all the patronage. The Emmet mill was forgotten by 1856 and brush and trees had so grown over the place that it seemed part of the original timber. The accumu-

lation of 12 to 14 feet of earth over the locality probably took place mostly soon after its abandonment, and certainly in less than 30 years. The general relations of these points is shown in Fig. 2.

The Old Holloway bridge and fence. Before the change of the Wabonsie to the west in 1875, the road ran westward from Holloway's house, near the egress of the creek, toward Bartlett. The course of this road is shown on the map, both going to Bartlett, and also southward by a crooked course. This is taken from a map first published in 1875 and indirectly throws important light on the character of the surface of the region at that time.

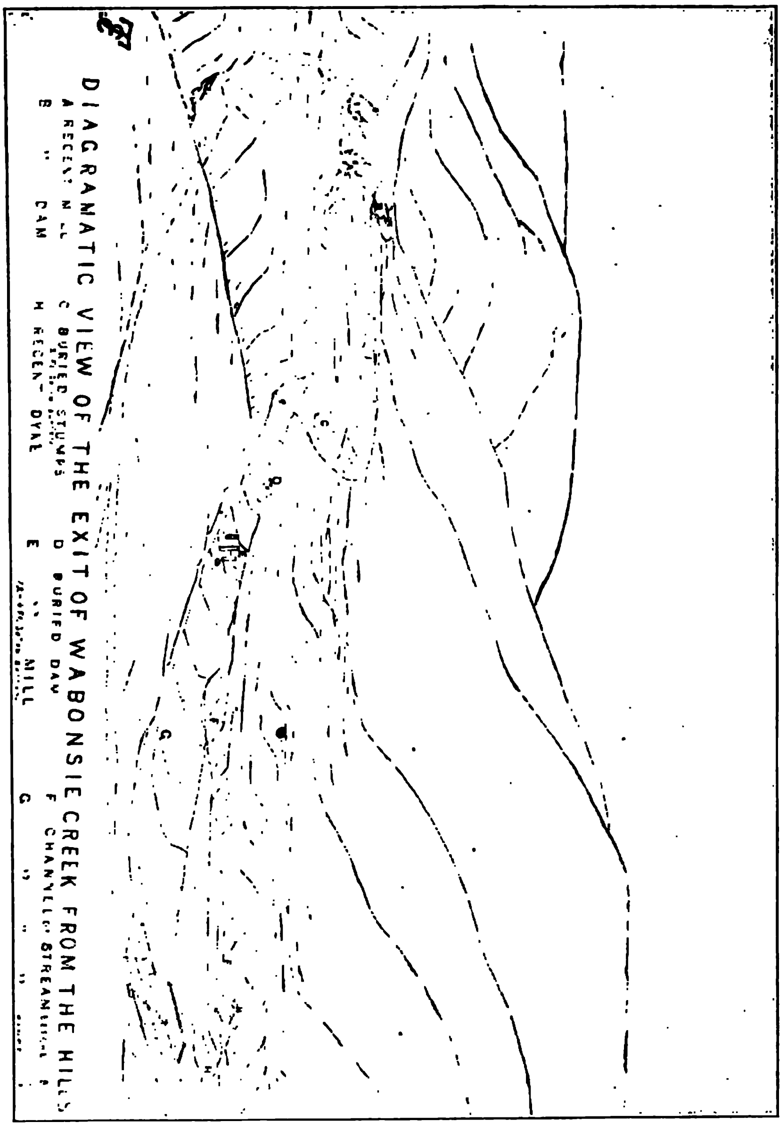
About half a mile west of Holloway's, a bridge was built over a channel-like slough. Different parties personally acquainted with the facts agree that when built the bridge was 14 feet above the ground in the slough. One says that one could drive under it readily with a wagon, that the posts resting on mud-sills were cut 14 feet long. When the creek turned west it ran to this point and through the slough northward to the north lake which it proceeded to fill with water and sediment. The latter was deposited about the bridge until it was covered and the surrounding fields filled up several feet. The fence on the west of Holloway's land was repeatedly buried. The third fence was put there in '83. One spoke of the fences as "10-foot" fences, another as "7-board" fences. Probably tall posts were put in, so that additional boards were added above as the lower ones were buried.

Returning to the old bridge, in the early '80's, possibly '81, Holloway tried to close the road across his farm and force the public to go around by his north line, which had now become passable. In the litigation which ensued, one had to dig several feet to reach the *top* of the buried bridge. Some say it was 6 feet deep, others 12 or 14. At that point therefore had been a fill of 20 to 30 feet in a little over 5 years, and probably of an average of 10 feet over many acres.

Meanwhile, Burson had given up trying to keep his mill and dam from washing out and left in '81.

A troublesome stream. After the Wabonsie had filled the northwest slope of its delta, raising its channel again considerably, it pushed on farther west to the channel in the west half of section 10, and found its way under the railroad bridge about a mile and a half south of Bartlett, but this course was so long and crooked and the stream carried so much debris that it had great difficulty in keeping a channel. It frequently overflowed the region widely. In 1896 a ditch was dug through the southeast corner of section

11, cutting off a large bend with the hope that it would keep open, but relief was only temporary, and about 1900 the creek began to



run from the place where it crossed Briley's slough, at the buried bridge, southward into the south lake which is its present course (1906).

Recent flood and fills. The delta or alluvial fan of the creek is, however, so built up that in case of unusual floods the tendency is strong for the creek to break over its banks as it bursts from the hills and for the last few years rapid deposition of sediment has taken place along the foot of the bluffs toward the south.

A series of floods occurred in '02 and '03 and less so in '04, of which the writer has gleaned the following notes which have been incorporated with the map. These floods have not risen quite 20 feet above the ordinary level of the creek at the bridge near the exit from the hills. The creek at that point is about 18 feet above the Missouri at low water, 3 miles west. That is, the water has been about 35 or 6 feet above the Missouri at that point. It is charged with abundant sediment, which is rapidly dropped as the velocity of the water is quickly checked after escaping from its narrow channel in the hills.

(At C) A few rods south of the bridge a young farmer showed the writer where he dug out his plow or cultivator after one flood and had it buried again, so that he claimed that sediment, at least 4 feet deep, had been laid down over several square rods in three days. He stated also that in one place he dug down 5 feet before he struck the roots of plants which grew on the old surface the season before.

(At D) In the southwest corner of the same section, a fill of 4 or 5 feet had taken place in the last 7 years according to the testimony of another, and the flood of 1904 washed the mud into the road just south so that it lay like snowdrifts in position and size in the lee of the fence posts and weeds, in places a foot deep.

(At E) A few rods farther south a stalk-rake having teeth 4 feet long was completely buried and the owner dug one foot to find it, showing according to his estimate a fill of about 4 feet. He said that he had 15 cords of piled cordwood also buried, but probably considerable of the top was washed away.

On the same quarter the house set up on blocks 2 feet high had its yard filled up nicely to the level of the sills. A similar service around the barn was less advantageous. The drawing, after a photograph, is a faithful presentation of it. (Fig. 3.) Being on lower ground, it was filled and the yard around it 3 or 4 feet, so that the door was too low for animals to enter and the joists of the hay loft too near the new ground for them to stand up easily. Since the sides of the barn were made of boards set vertically, the remedy was found by raising the floor of the loft 4 feet *and also the top* of the door, and by splicing the sides with short

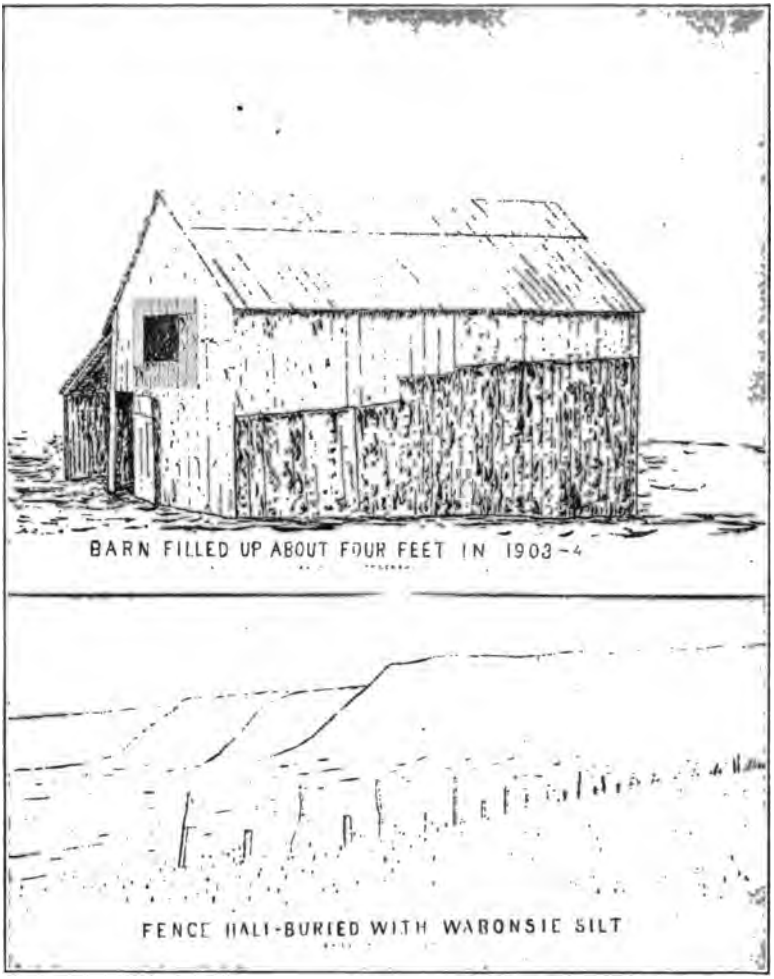


FIG. 3-A.

boards and putting on a new roof. Near by cultivators and wagons were dug out with much labor. A lister in the field back was dug out twice in three days, showing a fill of about 4 feet in that time.

Mr. Seth Dean, county surveyor of Mills county, a civil engineer of long experience in that region, from whom most of the altitudes for this paper have been obtained, says that in a single storm the Wabonsie has covered 100 acres one foot to a foot and a half, and argues that supposing the Missouri had occupied the north and south lakes at the same time and retired 100 years ago there has been time for the Wabonsie to have separated the lakes and built

up the extensive and fertile delta as we find it today. From data he has furnished, we learn that the level of the water under the bridge, near the buried mill, is 18.6 feet above the ordinary stage of the Missouri river west, about 6 feet above the railroad track at Bartlett, and 17 feet higher than where it runs under the railroad south of Bartlett. The level of the ground is 14.5 feet higher than the water, the floor of the bridge is 20 feet higher, and the level of an old alluvial terrace near by, probably marking the top of deposits antedating the occupation of the lakes by the Missouri, in fact recording adjustments long before that, which were similar to conditions before the stream broke west in 1875, is 26 feet above the water under the bridge or 44 feet above the Missouri three miles west, as before.

It should be stated that the water under the bridge is at present (1906) considerably higher than when the Burson mill had 20 feet fall, for as the bottom land has been built up in recent years the channel of the creek has risen also. Burson thinks the stream is nearly up to the level when he had 9 feet fall, and says the piling supporting the bridge where the gorge there was the deepest were 34 feet long, but it is more likely that it is at least 6 feet lower.

Fluctuations in level of the stream. We therefore see how the level of the stream at its debouchure, or egress from the hills, rises and falls with different conditions. Its lowest level would be when the Missouri comes to that side of its bottom land, when it would be nearly the same as the level of the river. Its level would be highest when the river is on the west side of its bottoms and the junction of the creek with the river very remote, and the whole course between built up to its highest grade. Such we may suppose to have been the case when the high terrace mentioned was formed.

Similar histories might be given for every stream entering the valley of the Missouri from the hills. North and south of the Wabonsie, every valley leading from the hills has a hillock or broad low swell of earth on the bottom in front of it. This is true except where there is evidence that the Missouri has recently occupied the place. The alluvial fans are frequently more abrupt and therefore more marked opposite smaller streams or dry valleys, because there has not been water enough to spread the silt. Similar general facts have been observed by the writer in northeastern Nebraska. Where the alluvial fans have been carried away by the river, there are still traces of the fluctuations of level in the valleys back from the river. We find flood-plains, sometimes with a fresh-cut ravine 10-20 feet deep revealing older bottoms with stumps upon them,

and also sometimes old ravines which have cut down to greater or less depth and then been refilled. Wood has been found buried 20, 30 even 40 or 50 feet in this way.

The antinquity of fossil human remains. The facts we have considered have an interesting bearing on the age of fossil human remains. One can readily see that all over the plain west of the debouchure of the Wabonsie the finding of boards, hewed sticks, brickbats, tin cans, etc., at the depth of 10, 15, 20 or even 25 feet would be nothing surprising, nor would it indicate an antiquity of more than 50 years, and in some cases the deposition may have been much more recent. The finding of such in the undisturbed material of the terrace might indicate an age of a century or two, antedating the formation of the south lake by the Missouri.

The Lansing Skull. This leads us naturally to speak of the so-called "Lansing Skull," much discussed in the papers 4 or 5 years ago. It was found under 20 feet of loamy earth, a few miles southeast of Lansing, Kan. It was in a loamy terrace in a small valley near its junction with the broad bottom lands of the Missouri. It was about 12 feet above the high water of 1881. The old Emmet mill is about the same height above the level of the same flood higher up the river.

Some prominent geologists, arguing that the loam of the terrace was as old as the mass of the loess, made the antiquity of the remains to be 10,000 to 50,000 years. Even the most conservative judged that "the antiquity of the burial is measured by the time occupied by the Missouri river in lowering its bottoms, two miles or more in width, somewhere from 15 to 25 feet, a very respectable antiquity, but much short of the glacial invasion." (Chamberlin, Journal of Geology, X, No. 7, 1902.)

But in the light of our study, we may read it still more recent. Without any lowering of the flood-plain of the Missouri, we may rationally explain it as follows: A small stream, probably flowing only part of the time, was discharging into the bottom land near. The Missouri which had been close at hand so that the stream had cut quite a channel in the underlying limestone, had swung off to the opposite side of the plain. The debris of the stream, especially in time of flood, began to accumulate and build up, just as we have seen in the case of the Wabonsie while the Emmet mill was being buried, and more lately since the stream broke west. The human skull (in fact we are told the remains are of a woman and child) may have been deposited in an overwhelming flood early in this stage. This continued till the body of the terrace 20 or 25 feet in

thickness had been deposited. Then, when the Missouri swung back to the west side of its flood-plain again, trace of which is seen in the fresh cliffs and steep bluffs facing the bottoms so close by, the little stream cut down to its present level. It is known to be only a few years since the river has again returned to the east of its valley, and the little stream has already begun to build a new alluvial fan or delta on the adjacent plain, though it has not yet begun to deposit between the hills.

The basin of the nameless water-course has only about a ninth or tenth of that of the Wabonsie, and consequently it would take much longer time to erode and deposit as much material, but on the other hand the water not being so abundant and constant might not distribute the material so widely. How far this might compensate cannot be estimated closely. A few centuries would seem to be ample estimate for the time since the burial of the "Lansing man."

EFFECTS OF CERTAIN CHARACTERISTICS OF ROCKS ON THEIR EROSION.

BY J. E. TODD.

A study of the streams of the western slope of the Missouri valley in South Dakota and northern Nebraska presents some striking contrasts. These are the more notable because the histories of the streams since the Tertiary have been much the same. At the opening of the Pleistocene, their courses were uniformly eastward from the mountains on the west to the master stream in the James River Valley. The Glacial Period resulted in the shifting of the latter westward to the present line of the Missouri above Yankton and it rapidly cut down to a grade of about one foot per mile. This quickened or rejuvenated all the streams considered.

We have the more reliable data of the two which are most sharply contrasted, viz., the Niobrara and the Cheyenne. These extend farthest west but the Grand, Moreau and White resemble more the Cheyenne than the Niobrara, in their original features.

The Niobrara has a quite uniform slope and simple structure, the Cheyenne has a gentle slope in its lower and middle course, and though its upper course is steeper it does not equal the slope which the former averages for its whole course. Moreover it has stolen the upper courses of its neighbors till it has monopolized the whole drainage of the Black Hills.

The slopes of the streams estimated from a few reliable data are shown in the following table:

Stream.	Miles.	Slope. Feet Per Mile.	Average.
Niobrara:			
Lusk to Marsland	65	11.6	....
Marsland to Valentine	140	11.8	....
Valentine to Niobrara	130	10.0	11.2
Cheyenne:			
N. Branch—Moorcroft to Stonesville Flats	70	11.4	....
N. Branch—Stoneville Flats to Fork	120	10.8	....
S. Branch—Edgemont to Fork	125	10.4	....
Main Stream—Fork to mouth	85	7.7	9.9

Reasons for a difference of slope of 1.3 feet per mile or nearly 2 feet if we restrict our view of the latter to its course from angle of

the Black Hills to the mouth, may be partly due to the greater volume of water in the Cheyenne, though that remains to be shown, and if shown it may still be referred as we shall see to the difference of rock in the two basins. Yet aside from this the character of the rock is argued to be the main cause for the apparent anomaly. The valley of the first stream is mostly in sand, of the second almost exclusively in clay, both little consolidated, or soft.

Two physical characteristics of these kinds of rocks seem to conspire to produce the results mentioned:

1. *Degree of porosity.* Sand is very porous; clay is very impervious, taking little water except near the surface. The former absorbs promptly a large proportion of the rainfall so that little runs off unless the rainfall is very copious. This tends to reduce the maximum of floods, the wash upon the surface and the vigor of the stream and moreover favors vegetation, which also tends to check erosion.

On the other hand clay absorbs little water; the rainfall nearly all runs off, producing sudden and severe floods, causing not only vigorous corrasion of water-courses but also frequent washing of the general surface.

2. *Coarseness of grain or size of particles.* Sand may be quite coarse and a fair proportion of gravel is found in the Miocene (Arikaree and Ogalalla), which constitutes most of the basin of the Niobrara. Even when the channel is cut from the underlying Pierre, as below Valentine, its course is largely lined with rearranged sands.

This feature affects the erosion in different ways. The coarseness of grain may aid the simpler or earlier stages of erosion, but seriously hinders indirectly, because it necessitates slower transportation; a fact which is now generally recognized. In time of flood, the coarser the material the greater the velocity before the material is moved, then it rapidly joins the stream and overloads it but is as rapidly dropped at the first checking of velocity, hence the tendency for streams dealing with such material to exhibit steeper slope, wider and shallower channels, such as is well illustrated in the Platte river of Nebraska. Therefore we find the Niobrara belonging to this class.

On the other hand, the Cheyenne works mainly in the clay shales of the Benton and Pierre formations and illustrates the results of erosion in clayey rocks. These are of very finely comminuted material which is easily mixed with water having the slightest motion, but when once mingled it separates very slowly, and is there-

fore carried far before it is redeposited. Hence it may be carried out of the region in a single season. Witness the muddiness of the Missouri and White rivers. Hence also the periphery of the stream is kept clear for corrasion by the small amount of coarse material which may be present and for the free wash of the stream. Over the whole surface, likewise, the plash of the rain and the wash of the rill easily produces perceptible erosion. Therefore the whole of a basin underlaid with clay is denuded rapidly. This is well illustrated by the Cheyenne which has a deeper valley and has captured the head waters of its neighbors so that it monopolizes the drainage of the Black Hills.

The two characteristics already considered are much the more prominent in effect, but another may be noticed which also sometimes has considerable effect. We may call it:

3. *Expansibility by moisture.* Sands and loams and consolidated rocks show but little if any expansion when moistened, but clays and earths often exhibit it in a high degree. This is seen in the slaking of lime, the similar heaving and cracking of the superficial layers of dry masses of clay and the converse is shown in mud-cracks.

The influence of this on erosion is obvious. A slight rain may open up the surface of a compact clay so that the winds or the next hard rain, or a more vigorous stage of the same shower, easily carries away the loosened particles. It tends to a kind of spheroidal weathering, resembling that produced by heat and frost in more consolidated rocks. This property is particularly efficient in producing "bad lands." It of course is most efficient where there are frequent and extreme changes from moisture to drouth, as where showers visit regions which are habitually dry. Absence of vegetation is both a result and an adjunct of this characteristic.

In leaving this suggestive study, a word should be said of White and Bad rivers which lie between the two specifically considered. The latter works almost entirely on Pierre clay like the Cheyenne, but lacks efficiency because of deficiency of water, but it shows great erosion and is subject to severe floods.

White River works very largely in Oligocene beds which are mostly clays and marly clays which are impervious and expand greatly with moisture. A limited amount of coarse material has on the whole rather helped erosion or compensated for rather greater hardness of rocks than is found in the Pierre. The valley has been greatly and deeply excavated. The presence of the Miocene sands and loams above the clays has complicated the results.

The underground waters in the sands, derived partly perhaps from the basin of the Niobrara, are brought to the surface by the underlying clays in springs which have assisted in the extending the basin toward the south. Hence the capture by the White of some important tributaries of the Niobrara. Possibly we may also see in this how the Cheyenne extended its tributaries southward at the expense of Bad and White rivers, for no doubt the sandy Miocene formerly extended more or less over that region with less thickness.

Less has been said here of these latter streams because data are lacking concerning their slopes and other features.

THE PHYSICAL SCIENCE LABORATORY OF THE STATE NORMAL.

BY A. C. PAGE.

The Physical Science Laboratory, now nearing completion, stands midway between the Auditorium and the Gymnasium at the north end of the quadrangle.

It is of fireproof construction, and is 112 feet, 6 inches long, 64 feet, 6 inches wide, and, from the ground floor, is four stories high.

The foundation is of Cedar Falls limestone and cement, the first story is built of Bedford, Ind., limestone, and the three stories above this are of Gladbrook red pressed brick, with a belting of Bedford stone between the third and fourth stories. Mason City hollow brick are used in the structure of the inner walls, and the ceilings and side walls are finished with hard plaster.

The floors and roof are made of concrete reinforced with expanded iron, the floors being finished with three inches of cement with colored border, and the roof with S tile. The roof-gutters and ventilator are of copper, the doors and casings are of quarter-sawn oak, and the stairs of iron.

The tables and apparatus cases were built at the school, of oak, Alberine stone being used for the table tops of hoods, and for the tables of weighing rooms.

The heating plant of the building includes the indirect fan system for day heating and ventilation, while the direct steam heating is employed when the laboratory is not in use, thermostats in all the rooms controlling the temperature. The building is furnished throughout with electric lights.

The laboratories are supplied with water, steam, gas, compressed air, electricity from a storage battery, and both the direct and alternating currents from the school and city plants respectively.

The ground floor provides three rooms to be used temporarily by the Geography department, a cloak room, two toilet rooms, and a store-room connected by a dumb-waiter shaft with similar rooms on the floors above.

The first floor is occupied by the Physics department: a general laboratory for the first three terms of study, a dark-room for photometer work, a laboratory for light and sound, a laboratory for mechanics and heat, a laboratory for electricity, a shop, a storage battery room, and a room for apparatus.

The second floor has a lecture hall for the use of both departments with a preparation room adjoining, a physics library, two lecture rooms, two instructors' offices, an apparatus room, and a cloak room.

The third floor is devoted to Chemistry, and includes a laboratory for general chemistry, a supply room for apparatus, a library, a private laboratory and preparation room, a lecture room with raised floor, a weighing room, a laboratory for quantitative work, a room for work with the microscope, polariscope, etc., a supply room for chemicals, and a cloak room.

The building is amply lighted, is well equipped with the best apparatus for the work to be done, and is a credit to the State which has provided it.

THE INNERVATION OF THE LATERAL LINE SYSTEM OF AMPHIUMA.

BY H. W. NORRIS.

Kingsbury[1] has given us an account of the general distribution of the sense-organs of the lateral line system in Amphiuma. According to him the arrangement in this form is almost typical of Amphibia. On the head: the supra-orbital group dorsal to the eye extends anteriorly to the tip of the snout; the infra-orbital group runs from the angle of the mouth ventral to the eye to the snout region; the oral line on the lower jaw passes along the lower lip; an angular series connects the oral with the infra-orbital; the gular series is found on the ventral surface of the head extending from the branchial region to the tip of the lower jaw; a post-orbital series passes posteriorly from the infra-orbital to meet the gular in the posterior branchial region; a jugular connects the angular with the meeting point of the gular and post-orbital. On the trunk are three longitudinal series: a dorsal, a lateral or median, and a ventral line.

This grouping of the sense-organs of the lateral line system in Amphiuma I find to correspond very closely to their innervation. As in Amphibia in general so in Amphiuma the lateral line organs are innervated by the so-called lateral line divisions of the seventh and tenth cranial nerves. The lateral line division of the seventh cranial nerve, the so-called "dorsal seventh," arises from the medulla oblongata by three rootlets. Of these the dorsal rootlet enters that portion of the medulla which in Necturus is designated by Kingsbury as the "dorsal island," a mass of alba occupying the extreme dorsal part of the medulla. This dorsal island suggests an homology to the lateral line lobe (lobus lineae lateralis) of Cyclostomes, Selachians and Ganoids, although Johnston[2] asserts that the lateral line lobe and the dorsal root of the dorsal VII are absent in aquatic Amphibia. In the fishes mentioned the lateral line fibers of the seventh nerve distributed to the neuromasts of the

1. Kingsbury, B. F. The Lateral Line System of Sense Organs in some American Amphibia, and Comparisons with Dipnoans. Proc. Amer. Micr. Soc., Vol. XVII, 1895.

2. Johnston, J. B. The Nervous System of Vertebrates, Philadelphia, 1906.

head arise from the medulla by two roots, a dorsal root from the lateral line lobe and a more ventral one from the acusticum. The dorsal island in the medulla of Necturus and Amphiuma seems to be the representative of the lateral line lobe of fishes, for into it passes the dorsal rootlet of the dorsal VII nerve, while the more ventral rootlets enter the underlying sensory column. In Amphiuma the dorsal island extends from a level a little posterior to the point of entrance of the lateralis root of the vagus nerve into the medulla to a level a little anterior to the entrance of the dorsal rootlet of the dorsal VII. Of the three rootlets of the dorsal VII the dorsal enters the brain a little posterior to the level of the others. In Amblystoma, according to Coghill,[3] the dorsal rootlet corresponds to the ophthalmicus superficialis VII. In Acanthias, according to Strong,[4] it is the mandibularis externus VII (mentalis VII) and buccalis VII branches that are related to the dorsal root, while the ophthalmicus superficialis VII enters chiefly the ventral root. Kingsbury[5] says that in Necturus the two roots of the dorsal VII do not correspond to divisions between the portions that join the V and VII nerves. In Amphiuma because of the intertwining of the fibers of the various rootlets it is difficult to distinguish between the portions that correspond to the different branches. Apparently the dorsal rootlet is derived largely from the mentalis VII (mandibularis externus VII), but the preparations do not permit exact statements in this regard.

From the points of entrance of the rootlets into the brain the root of the dorsal VII passes anteriorly as a flattened band closely compressed between the brain and the skull. From its ventral border many fibers pass antero-ventrally into the acustico-facial ganglion, a complex of ganglion cells from the auditory nerve, from the communis component of the VII nerve, and from the descending lateralis fibers just mentioned. The lateralis ganglion cells occupy the anterior ventral part of the mass, some of the cells crowding out a short distance with the exit of the VII nerve. As the VII nerve leaves the skull the lateralis component occupies the dorsal anterior part of the nerve trunk, and as the latter passes posteriorly comes to lie on the dorsal lateral border.

3. Coghill, G. E. The Cranial Nerves of Amblystoma tigrinum. Jour. Compar, Neurol., Vol. 12, No. 3, 1902.

4. Strong, O. S. The Cranial Nerves of Squalus acanthias. Abstract. Science, N. S., Vol. 17, No. 424, 1903.

5. Kingsbury, B. F. On the Brain of Necturus maculatus. Jour. Compar. Neurol., Vol. 5, 1895.

The first lateral line branch given off from the trunk of the seventh nerve is the ramus mentalis externus VII. At the point where this branch leaves the main trunk there arises either from the main trunk or from the lateral line ramus a small branch that divides into two or three divisions that supply the post-orbital and jugular series of neuromasts. It will be seen that this small branch with its divisions extends over a considerable territory. Dorsally it encroaches upon the occipital region so that a number of neuromasts included by Kingsbury in the dorsal series of the trunk are supplied by it. The R. mentalis externus VII supplies the oral and angular groups of neuromasts. Some distance posterior to the emergence of the R. mentalis externus VII another large lateral line ramus leaves the trunk of the seventh nerve to supply the gular series of neuromasts. This ramus is termed by Kingsley[6] as the R. hyomandibularis accessorius, and by Druner[7] as the R. cutaneus mandibulae medialis. This is evidently, as Druner recognizes, the ramus that in most Urodela arises with the R. mentalis externus in a common trunk from the seventh nerve. It is designated here as the R. mentalis internus VII, following the example of Coghill. Like the R. mentalis externus it consists solely of lateralis fibers.

Three or four neuromasts of the extreme posterior portion of the jugular series have a somewhat peculiar innervation. From the R. jugularis VII as it enters the kerato-mandibularis division of the depressor mandibulae muscle there are given off two small twigs that pass laterally and posteriorly out through the muscle and emerging subcutaneously, go one to the most dorsal of the neuromasts mentioned, while the second twig divides into three parts, one of these divisions supplying a second of these neuromasts, another division the third neuromast in part, and the third division joining a nerve that connects with that peculiar branch of the seventh nerve, designated by Druner as the N. lateralis VII. This latter nerve deserves a more extended mention. It was first described by Fischer[8] as a structure peculiar to Amphiuma and said to be traced to the hyotrachealis (interbranchialis IV) muscle. Kingsley believed that

6. Kingsley, J. S. The Cranial Nerves of Amphiuma. Tufts College Studies, No. 7, 1902.

7. Druner, L. Studien zur Anatomie der Zungenbein-, Kiemenbogen- und Kehlkopfmusculatur der Urodelen, II Theil. Zool. Jahrb., Abt., f. Anat. u. Ontog. d. Thiere, Bd. XIX, Hft. 3 u. 4, 1902.

8. Fischer, J. G. Anatomische Abhandlungen uber die Perennibranchiaten und Derotremen. Hamburg, 1864.

it supplied the dorsotrachealis muscle. In 1904 I read a paper[9] before the Iowa Academy of Sciences describing this nerve, showing that it did not end in the dorsotrachealis muscle, even if it supplied that muscle, but passed posteriorly into the trunk region as far posteriorly as the pelvis. I suggested a possible relation to the neuromasts of the trunk, and provisionally designated the nerve as the R. lateralis VII. In the same year appeared the paper of Druner in which he gave a brief description of the nerve, designating it as N. lateralis VII, asserting that it supplied in part the median series of neuromasts of the trunk, that is, he considered it as a lateral line nerve. The following year I published a second paper[10] in which I withheld the name, N. lateralis VII, believing that the evidence of the presence in it of lateralis fibers was not convincing. I can now assert with considerable confidence that the nerve contains lateralis fibers.

After the fibers destined to form the mentalis VII leave the trunk of the dorsal VII the latter passes anteriorly into its ganglion lying just dorsal to and confluent with the gasserian ganglion. Anteriorly to the ganglion the lateralis fibers are joined by general cutaneous fibers from the gasserian ganglion. The latter fibers are in two distinct bands, of which one is applied to the ventral and the other to the median surface of the lateralis trunk. As the combined nerves pass anteriorly the general cutaneous components shift their positions, the median band becoming dorsal and the ventral ones shifting to a lateral position. The main trunk soon divides into a dorsal and a ventral division, each consisting of lateralis and general cutaneous fibers. The ventral, or infra-orbital division, evidently represents the maxillaris V and the buccalis VII, while the dorsal supra-orbital portion is made up of an ophthalmicus superficialis VII and of what we may term the ophthalmicus superficialis V. Each division now divides into two rami. The infra-orbital trunk forms the maxillaris V, of general cutaneous fibers, and the buccalis VII, of lateral line fibers. The latter after giving off twigs to the posterior portion of the infra-orbital series of neuromasts divides into two branches. One of these, the dorsal and larger, unites with a branch of the ophthalmicus profundus nerve, and the combined trunk of general cutaneous and lateralis fibers, supplies the skin and the neuromasts of the infra-orbital series along the side of the snout. The smaller ventral branch of the

9. Norris, H. W. The So-called Dorsotrachealis Branch of the Seventh Cranial Nerve in Amphiuma. Proc. Iowa Acad. Sci., Vol. X, 1904.

10. Norris, H. W. The so-called Dorsotrachealis Branch of the Seventh Cranial Nerve *in Amphiuma. Anat. Anz.*, Bd. 27, 1905.

buccalis passes anteriorly and comes into close relation with another branch of the ophthalmicus profundus. I find no evidence that any anastomosing, such as Wilder[11] described, occurs between these two nerves except between some of their minute twigs. The buccalis branch supplies the infra-orbital neuromasts at the end of the snout. The supra-orbital division of the main trunk of the dorsal VII divides into a ventral branch, consisting entirely of lateralis fibers, and a dorsal branch containing both lateralis and general cutaneous fibers. The latter branch divides into a number of smaller divisions supplying the skin and the neuromasts of the supra-orbital series posterior to the eye. It should be noted that the transverse line of four or five neuromasts just at the posterior edge of the eye belongs to the infra-orbital series. The ventral branch passes anteriorly and dorsally and supplies the neuromasts of the orbital region, and then anastomoses with the median nasal branch of the ophthalmicus profundus. The mixed nerve thus formed supplies the skin and the supra-orbital series of neuromasts of the anterior dorsal region of the head.

The lateral line fibres of the tenth cranial nerve in Amphiuma enter the brain by the anterior root of the vagus ganglion. With them are associated the motor and communis components of the glossopharyngeal nerve. The lateralis fibers enter the medulla by two rootlets. At this level the lateral line lobe has nearly disappeared and the two rootlets correspond to the middle and the ventral rootlets of the dorsal VII. Four nerves containing lateralis fibers leave the vagus ganglion. The anterior of these is the R. supra-temporalis, composed exclusively of lateralis fibers. Before reaching the occipital series of neuromasts it anastomoses with the R. auricularis and thus comes to possess general cutaneous fibers. The auricularis branch leaves the vagus ganglion just posterior to the supra-temporalis. It contains both latéralis and general cutaneous fibres. After the anastomosing the combined nerves supply ten or twelve neuromasts in the occipital region. The R. lateralis medius leaves the posterior end of the vagus ganglion and passes posteriorly in a nearly straight line. It supplies the neuromasts of the median series of the trunk. Shortly after leaving the ganglion it gives off the R. lateralis superior that supplies the dorsal series of neuromasts of the trunk, not including those of the occipital region. The R. intestino-accessorius, com-

11. Wilder, H. H. Die Nasengegend von Menopoma alleghaniense und Amphiuma tridactylum. Zool, Jahrb., Abtheil. Anat., Bd. V. 1892.